Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION/DOWNGRADING SCHEDULE

3. DISTRIBUTION/AVAILABILITY OF REPORT
Approved for public release; distribution is unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
U.S. Army Engineer District, St Paul

6b. OFFICE SYMBOL (If applicable)

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
190 5th St. E.
St. Paul, MN 55101-1638

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING/SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Upper Mississippi River Hydrodynamics: discharge distribution in Pool 8, 1987-93.

12. PERSONAL AUTHOR(S)
Jon S. Hendrickson, Farley R. Haase, Michelle T. Hoff

13a. TYPE OF REPORT
Final

13b. TIME COVERED
FROM ______ TO ______

14. DATE OF REPORT (Year, Month, Day)
9506

15. PAGE COUNT

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
CHANNEL FLOW
UPPER MISSISSIPPI RIVER

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A current trend in many reaches on the Upper Mississippi river is one of increased hydraulic conveyance through backwater areas with subsequent decreases in navigation channel flows. This increases both the sediment load to backwaters and the amount of navigation channel shoaling requiring maintenance dredging. During the last 20 years, The St. Paul District, Corps of Engineers has implemented several projects to reverse this trend. As part of these projects, discharge measurements have been dome to quantify flow distributions. In pool 8, a fairly extensive data base of discharge measurements exists.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL

22b. TELEPHONE (Include Area Code)

22c. OFFICE SYMBOL

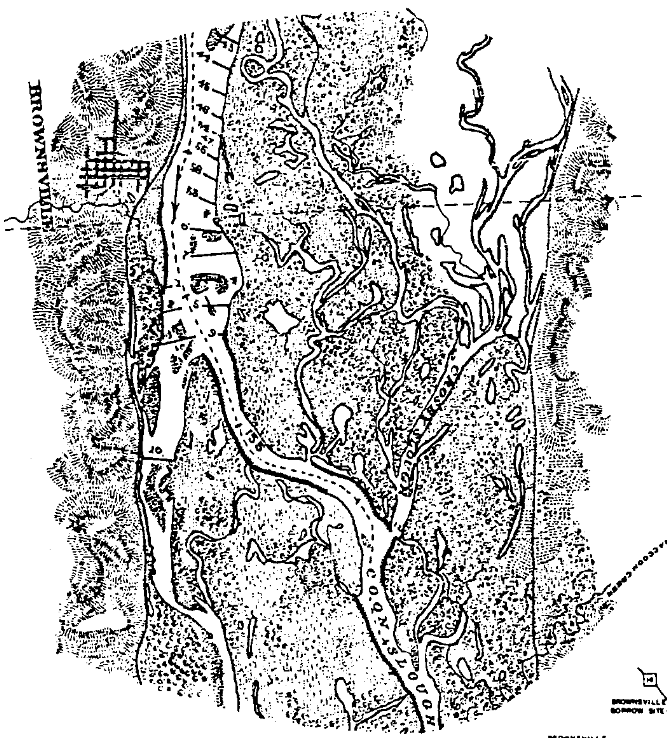
DD FORM 1473, 84 MAR

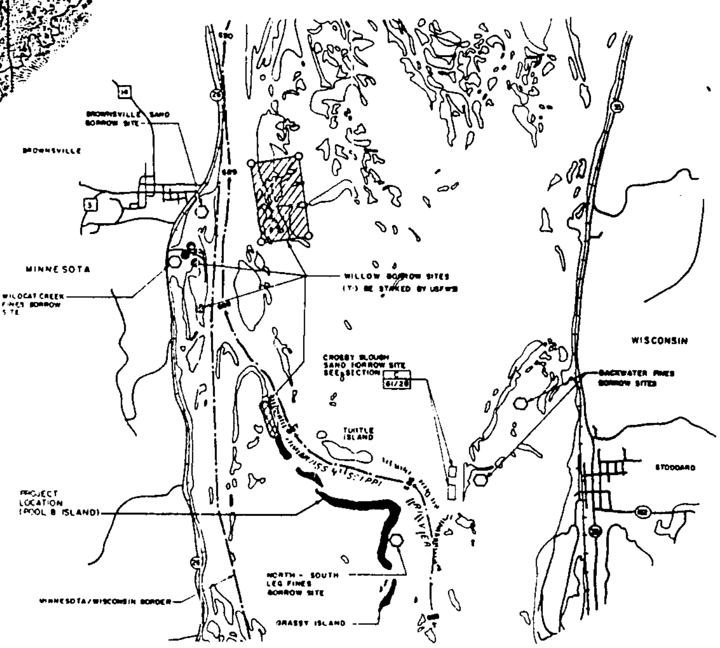
83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

US Army Corps
of Engineers
St. Paul District

UPPER MISSISSIPPI RIVER HYDRODYNAMICS: DISCHARGE DISTRIBUTION IN POOL 8, 1987-93





JUNE 1994

US Army Corps
of Engineers
St. Paul District

UPPER MISSISSIPPI RIVER HYDRODYNAMICS: DISCHARGE DISTRIBUTION IN POOL 8, 1987-93

by
JON S. HENDRICKSON, P.E.
FARLEY R. HAASE
MICHELLE T. HOFF

Engineering and Planning Division

U.S. Army Corps of Engineers
Army Corps of Engineers Centre
190 Fifth Street East
St Paul, Minnesota, 55101-1638

JUNE 1994

CONTENTS

TABLES

FIGURES

CONVERSION FACTORS

Multiply	By	To Obtain
cubic feet per second (cfs)	0.02832	cubic meters per second
miles	1.609	kilometers
square miles	2.590	square kilometers
feet per second (fps)	0.305	meters per second
square feet	0.093	square meters

UPPER MISSISSIPPI RIVER HYDRODYNAMICS:
DISCHARGE DISTRIBUTION IN POOL 8
1987-93

by

Jon S. Hendrickson, P.E.
Farley R. Haase
Michelle T. Hoff

ABSTRACT

A current trend in many reaches on the Upper Mississippi River is one of increased hydraulic conveyance through backwater areas with subsequent decreases in navigation channel flows. This increases both the sediment load to backwaters and the amount of navigation channel shoaling requiring maintenance dredging. During the last 20 years several projects have been implemented by the St. Paul District Corps of Engineers to reverse this trend. As part of the study and design of these projects, discharge measurements have been done to quantify flow distributions. Although this data is obtained for specific projects covering small river reaches, a comprehensive view of the flow distribution in a pool can be obtained when data from several projects is combined. The view is increased further when data from adjacent pools is combined. And with more data collection, what emerges is one element of the "big picture look at the River" advocated by those involved with the rivers natural resources. In Pool 8, a fairly extensive data base of discharge measurements exists. By itself, the data accomplishes three things. First, past and present flow distributions are quantified; second a baseline for future investigations is established; and third, a foundation for more detailed mass transport studies of the river has been created. Based on this data, pool 8 can be divided into 3 distinct reaches. In the upstream reach, the majority of the river flow (80 to 100-percent) is conveyed in the navigation channel. In the downstream reach, only 30-percent of the river flow is conveyed in the navigation channel, with the rest conveyed through backwater areas. Significant flow breakouts occur in the middle reach with a reduction in the flow conveyed in the navigation channel from 100-percent at the upper end to 29-percent at the lower end of this reach. The majority of channel maintenance dredging in Pool 8 is done in this middle reach. Construction of islands in lower Pool 8 has affected local hydrodynamics, but hasn't greatly altered lateral and longitudinal flow distributions on a pool-wide scale.

INTRODUCTION

Discharge measurements collected in Pool 8 of the Upper Mississippi River from 1987 to 1993 are summarized in this report. These measurements were done in conjunction with the Lower Pool 8 Island HREP (Habitat Rehabilitation and Enhancement Project), the East Channel/Smith Slough HREP, and the navigation channel maintenance program. The HREP's are part of the Upper Mississippi River EMP (Environmental Management Program). The purpose of the monitoring was to establish preproject flow distributions and determine hydrodynamic impacts of project construction. Discharge data presented here was collected

by the USCOE (U.S. Army Corps of Engineers, St. Paul District), Barr Engineering Company, Minneapolis, Minnesota (Reference 2), the USGS (United States Geologic Survey, Minnesota Office), and the WDNR (Wisconsin Department of Natural Resources, La Crosse Office).

The lower Pool 8 study reach can be divided into five primary hydrodynamic areas. These areas (Figure 1) are the Raft Channel, the navigation channel (Coon Slough), the Crosby Slough area, Phase 1 of the Pool 8 Islands HREP, and Stoddard Bay (Phase 2 of the Pool 8 Islands HREP). Phase 1, Stage 1 of the Pool 8 project was constructed in July 1989 using sand dredged from the adjacent navigation channel. The purpose of this project stage was to reduce backwater inflows and rebuild Horseshoe Island located on the right descending side of the navigation channel between river miles 687 and 687.6 (Figure 1). Two tertiary channels (sites 4 and 5) through the island were closed as part of this work. While this had a local effect on discharges, the total river discharge affected was only 1-percent, resulting in a negligible effect on flow distributions in lower Pool 8. Therefore, discharge data collected before and after the Phase 1, Stage 1 island was constructed is considered to represent the same conditions in lower Pool 8. Phase 1, Stage 2 of the Pool 8 project was constructed between April and October, 1992, resulting in a 1.5-mile long island (Boomerang Island) between river miles 685.3 and 687.1. The purpose of this project stage was to partially isolate the downstream backwater area from river flows and wave action. Discharge measurements were done in 1993 to determine the impacts of Phase 1, Stage 2. Phase 2 of the Pool 8 Islands HREP is currently being studied and designed.

The East Channel/Smith Slough study area is located at the upstream end of Pool 8 (Figure 2). The project is currently being studied and designed and discharge data is being collected at secondary channels to establish preproject conditions and for use in design.

The terms primary, secondary, and tertiary are used to describe various channels that convey water. The primary channel generally is the navigation channel and secondary channels are those that convey water from the navigation channel into the backwaters. Tertiary channels are those that split off from secondary channels.

METHODOLOGY

Discharge measurements collected by USCOE personnel were done from a 20-foot Pontoon boat using a type-AA Price current meter. Boat position was determined using a Cubic Precision, Pulse Ranger, electronic distance meter. A Loran-C positioning system was employed on a number of occasions also. Depending on channel geometry the methods employed to maintain a stationary boat position included: a tag line (cable stretched across the channel), boat anchors, or spuds (vertical poles placed through sleeves on the boat and into the bottom). Channel discharge was determined by dividing the cross section into variable width subsections as recommended by the USGS (Buchanan and Somers 1969) with the exception that the number of subsections used at each cross section usually was limited to about ten. In each subsection the water depth (feet) and velocity (feet per second) at 8/10 and 2/10 depth was determined. If the water depth was less than 2.5 feet, a single velocity measurement was taken at 6/10 depth (measured from the surface). In each subsection, the cross sectional area (square feet) was determined by multiplying the water depth by the width, and the average velocity was determined by calculating the

average of the 8/10 and 2/10 depth velocity readings (or by using the measurement at 6/10 depth). When the streamlines weren't perpendicular to the cross section line, the average velocity was reduced by the sine of the acute angle between the streamline and the cross section line. The subsection discharge (cubic feet per second) was determined by multiplying the subsection area by the average velocity and the total cross section discharge was calculated by summing the subsection discharges. Similar techniques were used by other investigators.

Discharge measurement errors are a function of several factors. At velocities less than 0.2 fps, the accuracy of the Price Meter decreases. Wind and waves may cause vertical and horizontal boat movement resulting in errors in measured velocities which tend to be magnified for low flow conditions. An analysis of these errors is found in Kalio (1966). Large commercial vessels may temporarily change secondary channel discharges. And Lock and Dam operation may affect local hydrodynamics. In addition, discharge at a site can change over time due to aquatic vegetation density, and sediment deposition or erosion. As a check on discharge measurement integrity, the calculated Lock and Dam discharge is compared to the measured discharge in the adjacent pool on those occasions when the data collection effort results in measurement of the total river discharge. These comparisons are summarized in Table 1. The difference between measured discharge and the average Lock and Dam discharge ranged from 0.2-percent to 20.3-percent, with a mean of 8.0-percent. The measurements done between June and November, 1993 in pools 8 and 9 differ significantly with those recorded at the lock and dam; in most cases the measured discharge being lower than the lock and dam discharge. The estimated discharge at Lock and Dam 8 was used for these comparisons except for the 7/7/93 measurement in Pool 9. It appears that significant errors exist in either the measured discharge or the estimated Lock and Dam 8 discharge. No effort has been made to correct the measured data based on these differences.

Table 1. Comparison Between Measured Total River Discharge and Total River Discharge Calculated at Lock and Dam.

Lock and Dam Discharge Range (cfs)	Lock and Dam Average Discharge (cfs)	Total Measured Discharge (cfs)	Difference (%)	Date	Location	Lock and Dam used
18,600 - 18,700	18,600	18,565	0.2	8/22/91	Pool 3	3
64,700 - 66,550	65,705	59,425	9.6	3/31-4/01/92	Pool 5	5
23,650 - 25,900	24,600	23,257	5.5	8/27-8/29/91	Pool 5A	5A
69,525 - 70,700	69,916	63,725	8.8	8/12-8/13/93	Pool 5A	5A
77,400 - 86,600	81,581	74,701	8.4	4/02-4/04/91	Pool 7	7
60,150 - 61,825	60,771	57,691	5.1	4/15-4/17/91	Pool 7	7
35,525 - 36,400	35,923	32,147	10.5	8/06-8/07/91	Pool 7	7
31,150 - 42,600	37,544	37,846	0.8	9/10-9/12/91	Pool 7	7
55,500 - 56,500	56,029	58,089	3.7	7/14-7/15/92	Pool 7	7
20,400 - 20,500	20,438	22,517	10.2	9/23-9/25/87	Pool 8	8
116,300 - 117,400	116,864	109,605	6.2	4/21-4/22/93	Pool 8	8
81,300 - 82,150	81,761	86,513	5.8	5/03-5/05/93	Pool 8	8
77,850 - 79,800	78,850	89,870	14.0	6/14-6/18/93	Pool 8	8
72,100 - 72,800	72,396	63,031	12.9	8/05-8/07/93	Pool 8	8
47,350 - 51,200	48,193	43,050	10.6	9/21-9/23/93	Pool 8	8
27,400 - 28,750	27,765	22,126	20.3	11/3-11/5/93	Pool 8	8
75,900 - 76,625	76,263	74,414	2.4	8/02/93	Pool 9	8
170,550 - 172,025	171,400	148,764	13.2	7/07/93	Pool 9	9
53,475 - 55,450	54,483	51,952	4.6	9/22/93	Pool 10	9

Because the total Mississippi River discharge can change significantly over the length of time (3 to 4 days) required to collect a complete set of discharge measurements, it is usually not possible to directly measure the discharge distribution across the river valley. Rather, discharge rating curves for each site are developed from data pairs of site discharge versus total river discharge. Discharge rating curves for larger areas are then developed by summing the discharges obtained from the discharge rating curves for individual sites. Where applicable, the discharge rating curves are adjusted based on the differences in Table 1.

Lock and dam discharges are calculated on-site and transferred to the St. Paul District WCC (Water Control Center) each day. The 8 AM lock and dam discharge is stored in the data base.

DATA MANAGEMENT

Discharge measurements currently are archived on a data base system maintained on an AT&T 3b2-1000 mini-computer by the St. Paul District Hydraulics Section. Data pairs of site discharge versus lock and dam discharge are stored in ASCII format. This data can be obtained by contacting the St. Paul District Hydraulics Section. All of the discharge data collected to date is presented in this report in either tabular or graphical format or both.

Lock and dam discharge data is stored at the St. Paul District WCC Office. This data can be obtained by contacting the St. Paul District WCC Office.

HYDROLOGY

The Mississippi River at Lock and Dam 8 has a drainage basin area of 64,770 square miles and an average discharge of approximately 34,940 cfs. The main tributaries in Pool 8 are the LaCrosse River (480 square mile drainage area) which enters at river mile 698.2 and the Root River (1660 square mile drainage area) which enters at river mile 693.7. The construction of Lock and Dam 7 in 1937 cut off the Black River so that physically it enters pool 7. However, the cut off channel in upper Pool 8 continues to be called the Black River, and indeed Black River water entering Pool 7 ends up in this cut off channel via Lake Onalaska and the Onalaska Spillway

Snowmelt runoff usually causes peak annual discharges on the Mississippi River and its tributaries in the Spring with discharges decreasing throughout the summer until fall, when there is often a slight increase in discharge. Spring discharges at Lock and Dam 8 typically exceed 80,000 cfs while a typical summer low discharge is less than 20,000 cfs. Tributary discharges are strongly affected by rainfall events which occur throughout the summer. In some cases (ie. 1993 flood) the Mississippi River is influenced by summer rainfall events also. Time and length scales for flood events differ greatly between the Mississippi and its tributaries - a flood wave may move down a tributary in a few days while a flood wave on the Mississippi may take several weeks or months to pass.

Tables 2 and 3 contain discharge-duration and discharge-frequency information for Lock and Dams 7 and 8.

Table 2. Discharge - Duration, Lock and Dams 7 and 8.

Percent of Time Exceeded	Mississippi River Discharge Lock and Dam 7 (cfs)	Lock and Dam 8 (cfs)
1	123,900	131,600
10	68,800	73,900
20	51,300	55,000
30	39,200	42,600
40	31,200	33,800
50	25,400	27,300
60	20,700	22,300
70	17,000	18,600
80	14,000	15,500
90	11,100	12,200
100	2,500	2,500

Table 3. Discharge-Frequency, Lock and Dams 7 and 8.

Time of Return (Years)	Mississippi River Discharge Lock and Dam 7 (cfs)	Lock and Dam 8 (cfs)
2	91,000	94,000
5	130,000	134,000
10	157,000	161,000
50	221,000	224,000
100	252,000	254,000
500	320,000	321,000

DISCHARGE DISTRIBUTION

Introduction

Site locations where discharge measurements were taken are shown on Figures 1 and 2. Sites are delineated by a number or common name (ie. Smith Slough) with an arrow pointing to the approximate measurement location. Each measurement location is also given a site location number (used in tables and figures), which identifies the site first by river mile and then by orientation and distance from the navigation channel. The distance and orientation are based on the center of the navigation channel and site cross sections. As an example, the site location number for site 1 in lower Pool 8 is 687.5 W (2000'), which means site 1 is located 2000 feet west of the navigation channel at river mile 687.5.

Individual discharge measurements taken at sites in Pool 8 can be found in the Appendix to this report. Data has been collected at lock and dam discharges ranging from typical low flow conditions of 17,000 cfs to 25-percent chance (4-year) flood conditions of 120,000 cfs. Site discharge versus total river discharge at Lock and Dam 8 for the sites in lower Pool 8 is shown on Figures 3 through 30. Figures 31 through 38 show site discharge versus total river discharge at Lock and Dam 7 for sites in upper Pool 8. Actual measured data points on Figures 3 through 38 are represented by circles.

In the following paragraphs, site discharge is discussed as a percentage of total river discharge (or reference discharge) at the upstream or downstream lock and dam. To facilitate this discussion, the percentages given are for a reference discharge of 50,000 cfs unless stated otherwise. If information for a different discharge is desired, the discharge rating curves should be consulted. The data in lower Pool 8 is divided into two time periods; 1987 to 1992, and 1993 (before and after construction of the Pool 8 Islands HREP Phase 1, Stage 2). The only exception is the discussion on the local changes at sites 3, 4, and 5 due to Phase 1, Stage 1 construction in 1989. The results

are presented by hydrodynamic area with the Pool 8 HREP, Phase 1 area divided into Horseshoe Island (Stage 1) and Boomerang Island (Stage 2) and the Pool 8 HREP, Phase 2 area divided into Stoddard Bay and Trapping and Heron Islands (Table 4). In upper Pool 8, only data from 1992-93 is available.

Table 4. Primary Hydrodynamic Areas and Corresponding Sites in Lower Pool 8.

Hydrodynamic Area	Corresponding Sites
Raft Channel	1, 2, 3
Coon Slough (Navigation Channel)	6
Crosby Slough	7, 8, 9, 10
Pool 8 HREP, Phase 1	
Horseshoe Island (Stage 1)	4, 5
Boomerang Island (Stage 2)	13, 14, 20, 22, 23
Pool 8 HREP, Phase 2	
Stoddard Bay	11, 12, or 26
Trapping and Heron Island	24, 25

Raft Channel

For the period 1987-92, the combined discharge through sites 1, 2, and 3 amounted to 17.9-percent of the total river discharge. Sites 1 and 2 conveyed significant amounts of flow, with 8.7-percent and 6.7-percent of the total river discharge. The discharge at site 3 decreased from 2.5-percent in 1987-89 to 1.5-percent in 1990-92. This is apparently associated with construction of Phase 1, Stage 1 of the Pool 8 Island HREP.

In 1993, the combined discharge through sites 1, 2, and 3 had increased slightly, amounting to 18.4-percent of the total river discharge. Sites 1 and 2 conveyed 9.2-percent and 7.0-percent of the total. The discharge at site 3 had increased from 1990-92 conditions to 2.2-percent.

Navigation Channel (Coon Slough)

The discharge in the navigation channel at site 6 equaled approximately 30-percent of the total river discharge during the 1987-92 period. In 1993, this had been reduced slightly to 29-percent.

Crosby Slough Area

Two methods of measuring discharge were used in this area. The first being individual measurements at sites 8, 9, and 10 (Figures 10, 11, 12), the second being measurements along a single transect from the east end of Turtle Island easterly to the Stoddard Island Remnants which are on the east side of Crosby Slough. Data from the single transect (designated Site 8/9/10) is plotted on Figure 13 along with the summation of discharges from sites 8, 9, and 10.

For the period 1987-92, the combined discharge through sites 8, 9, and 10 amounted to 40.9-percent of the total river discharge. Site 10, which includes Crosby Slough, conveyed 17.3-percent of the total river discharge. Site 9 conveyed 13.8-percent and site 8 conveyed 7.6-percent of the total. The discharge at site 7 is bidirectional entering or leaving the navigation channel depending on hydrodynamic conditions.

In 1993, the combined discharge through sites 8, 9, and 10 had increased to 42.0-percent of the total river discharge. Site 10 now conveyed, 21.8-percent of the total discharge, while sites 8 and 9 conveyed 8.0-percent and 9.6-percent respectively. The greater increase in discharge at site 10, as compared to site 8 where there was little change and site 9 where there was a decrease, is probably due to construction of the Pool 8 HREP, Phase 1, Stage 1 Island in 1992 which caused a shift in flow to the east.

Stoddard Bay (Pool 8 HREP, Phase 2)

Discharge in this area has been measured at its upstream end at sites 11 and 12 and at the downstream end at site 26. Breaches in the chain of islands on the west side of this area convey significant quantities of water causing increased discharge at site 26, over that at sites 11 and 12. During the low flow conditions of 1987, sites 11 and 12 were defined channels, with an extensive vegetation bed between them that conveyed little water. During high flow conditions, the vegetation bed conveys water, however it is difficult to get discharge measurements because of the vegetation and stumps. A single measurement was taken along a transect across the entire area in 1993 when the total river flow was 81,000 cfs. The single transect is designated site 11/12 on figure 1 and the measurement at this site is shown on Figure 17 along with data points representing the combined flow at sites 11 and 12 measured on other dates. For low flow conditions (ie. Lock and Dam 8 discharge less than 50,000 cfs) the combined flow data points adequately represent the total flow through this area, however for high flows, there is some unmeasured flow in the vegetation bed. This was accounted for when the rating curve on Figure 17 was drawn.

For the period 1987-92, the combined discharge through sites 11 and 12 was 2.5-percent of the total river discharge, with site 11 conveying .8-percent and site 12 conveying 1.7-percent. The only discharge measurement at site 26 during this time period was done in April 1992 at a total river flow of 92,000 cfs. Based on this measurement, this site conveyed 17.53-percent of the total discharge. Since the data point at site 26 represents a significantly higher flow condition than the data at sites 11 and 12, comparisons should be made with caution.

In 1993, the combined discharge through sites 11 and 12 had increased to 4.8-percent of the total river discharge, with site 11 conveying 2.7-percent of the total and site 12 conveying 2.1-percent. This increase may be due to Pool 8 HREP island construction, however other factors may have affected hydrodynamic conditions at this site in 1993, most notably the decrease in aquatic vegetation density. Site 26 conveyed 11.2-percent of the total river flow, over twice that at sites 11 and 12. This indicates that flow through the chain of islands on the west side of this area is significant. And since the percentage of flow conveyed through this area increases with increasing river discharge flow conveyance over the Island remnants becomes more efficient with greater submergence. The single data point collected at site 26 in April 1992, fits the 1993 data very well.

Horseshoe Island (Pool 8 HREP, Phase 1, Stage 1)

Because of data limitations, the reference discharge used in this section will be 20,000 cfs instead of 50,000 cfs.

Prior to construction of Phase 1, Stage 1 of the Pool 8 Islands HREP, sites 4 and 5 each conveyed 0.55-percent of the total river discharge. Both sites were closed as part of the HREP.

Boomerang Island (Pool 8 HREP, Phase 1, Stage 2)

Sites 13, 20 and 22 were closed and the head of Benover Slough (site 14) was relocated to site 28 as part of the Phase 1, Stage 2 HREP. Because of data limitations, the reference discharge used in this section will be 80,000 cfs instead of 50,000 cfs.

For the period 1987-92, the total flow into the Phase 1, Stage 2 area was 14.6-percent of the total river discharge. Sites 13, 14, and 20 conveyed 1.5-percent, 1.9-percent, and 8.9-percent of the total. Flow at site 22 was bidirectional since the site was oriented with the primary flow direction. Site 23 conveyed 2.3-percent of the total river flow.

After Phase 1, Stage 2 construction, the flow conveyed into this area was reduced to 6.3-percent of the total. Site 28 conveyed 1.9-percent and discharge conveyed at site 23 increased to 4.4-percent of the total. As part of the Benover Slough relocation, one of the goals was to maintain the same amount of flow conveyance - this appears to have been accomplished.

Trapping and Heron Islands (Pool 8 HREP, Phase 2)

Discharge data was also collected at sites 24 and 25 to determine the impacts of the Pool 8 Island HREP, Phase 1, Stage 2. Because of data limitations, the reference discharge used in this section will again be 80,000 cfs instead of 50,000 cfs. For the period 1987-92, sites 24 and 25 conveyed 8.3-percent and 4.1-percent of total river flow respectively. After phase 1, stage 2 construction, flow through these two sites increased to 10.1-percent and 5.5-percent of the total.

Upper Pool 8

The combined flow through the three inlets to East Channel (Figures 31, 32, and 33), amounts to 15.6-percent of the total river flow at Lock and Dam 7. The two largest inlets, at river miles 701.7 and 701.4, convey 8.7-percent and 6.5-percent of the total. The downstream inlet is relatively small, conveying only 0.4-percent of the total. Smith Slough, a tertiary channel of East Channel, conveys 1.1-percent of the total. Measurements taken on June 3, 1993 at the upstream and downstream end of Smith Slough indicate a significant amount of breakout flow. The breakout occurred over the right bank natural levee and caused the Smith Slough flow to decrease from 2.6-percent to 1.2-percent of the total river discharge of 77,000 cfs on that date. The flow in French Slough, which receives water from Smith Slough and the French Island Spillway at Dam 7, is 1.4-percent. Based on one measurement, obtained at a total river discharge of 78,000 cfs, West Channel conveys 19.3-percent of the total flow. Flow through the Onalaska Spillway during 1992 and 1993, as measured at Black River Mile 4.8, fluctuated between 1,269 and 1,650 cfs. A discharge measurement done in 1987 at Black River Mile 0.7 indicates the discharge at this time amounted to 1,410 cfs.

CONCLUSION

The data presented here quantifies past and present flow conditions in Pool 8 and provides a baseline for future investigations. In addition, this data forms a foundation for doing more detailed mass transport studies of the river. Whether the interest be habitat improvement or channel maintenance,

knowledge of the source and fate of water in a given area is important. Specific conclusions that can be drawn include:

1. The discharge distribution in lower Pool 8 for the 1987-92 and 1993 time periods is shown on Figure 39 and in Table 5. These distributions were developed based on data obtained at sites located in each hydrodynamic area (Table 4). Construction of Phase 1 of the Pool 8 Islands HREP reduced flow into the Phase 1 area from 15.7-percent to 6.3-percent of the total river discharge (reference river discharge equals 50,000 cfs). Most of the displaced water apparently is conveyed in the navigation channel although transect locations in lower Pool 8 are such that this hasn't been measured (ie. site 6 is upstream of the reach where phase 1 would have an impact). This is consistent with findings in Pool 5 for the Weaver Bottoms Project (Hendrickson and Haase 1993). Relatively minor increases in discharge were measured in Raft Channel and Crosby Slough. Not enough "pre-phase 1" data was available at site 26 in Stoddard Bay to determine impacts. The flow in the Trapping and Heron Islands area showed the most significant increase in flow from 12.4 to 15.6-percent of the total river discharge.

Table 5. Percent of Total River Discharge Conveyed in Each Hydrodynamic Area in Lower Pool 8 for the 1987-92 and 1993 Time Periods for Lock and Dam 8 Discharges of 20,000, 50,000, and 80,000 cfs.

	20,000 cfs		50,000 cfs		80,000 cfs	
Hydrodynamic Area	1987-92	1993	1987-92	1993	1987-92	1993
Raft Channel	24.8	20.8	17.9	18.4	16.8	17.9
Coon Slough (Navigation Channel)	37.5	39.0	30.0	29.0	23.7	22.2
Crosby Slough	34.0	29.0	40.9	42.0	42.5	43.6
Pool 8 HREP, Phase 1						
Horseshoe Island (Stage 1)	1.1	0.0	1.1	0.0	-	0.0
Boomerang Island (Stage 2)	-	5.3	14.6	6.3	13.7	6.4
Pool 8 HREP, Phase 2						
Stoddard Bay Area (Site 26)	-	11.2	-	11.2	-	16.2
Trapping and Heron Islands	-	13.7	12.4	15.6	12.4	15.6

Note: "-" Data Not Available

2. Upper Pool 8 differs significantly from lower Pool 8 in that 80 to 100-percent of the total river flow is conveyed in the navigation channel compared to 30-percent in the lower pool. East Channel conveys 15.6-percent of the total river flow at Lock and Dam 7 while West Channel conveys 19.3-percent. Smith and French Sloughs convey approximately 1.1 and 1.4-percent of the total. The range of flows measured in the Black River Channel correlate well with the design discharge of the Onalaska Spillway.

3. The percentage of the total river discharge conveyed in the navigation channel varies longitudinally (Table 6) due to split flows to backwater areas. Although the sparsity of data prevents a rigorous analysis, it is quite clear that the flow conveyed in the navigation channel decreases significantly with distance downstream. Essentially, Pool 8 can be divided into 3 reaches based on the discharge conveyed in the navigation channel. Upper reach (river miles 695.0 to 702.5) navigation channel discharges vary from 80 to 100-percent of the total river flow. Middle reach (river miles 687.5 to 695.0) navigation

channel discharges decrease from 100-percent of the total river discharge at the upper end to 29-percent of the total at the lower end of this reach. Lower reach (river miles 679.2 to 687.5) navigation channel discharges account for about 30-percent of the total river discharge. Significantly the majority of dredging in Pool 8 is done in the middle reach where the greatest amount of split flow occurs.

Table 6. Percentage of Total River Discharge conveyed in the Navigation Channel by River Mile.

River Mile	Percent of Total River Discharge in the Navigation Channel
700	81 (total river flow = 50,000 cfs)
698	81 (total river flow = 78,000 cfs)
695	100 (total river flow = 50,000 cfs)
691.6	73 (total river flow = 46,300 cfs)
688.0	41 (total river flow = 94,000 cfs)
687.5	29 (total river flow = 50,000 cfs)
683.3	27 (total river flow = 46,000 cfs

Discharge data will continue to be collected on a project basis. With Phase 2 of the Pool 8 Islands HREP currently being studied and designed, the data base in lower Pool 8 will be expanded. Consideration should be given to monitoring secondary channels in the middle reach of Pool 8 to better quantify flows in this reach. Both backwater habitat improvement and channel maintenance efforts would benefit from such data.

REFERENCES

1. Buchanan, T.J. and W.P. Somers (1969). Discharge Measurements at Gaging Stations. Techniques of Water-Resources Investigations of the United States Geological Survey. Book 3, Chapter A8.

2. Barr Engineering Company (1993). Discharge Distribution Summary and Report: Summer and Fall, 1993 Mississippi River Channels Flow Measurements. Prepared for U.S. Army Corps of Engineers St. Paul, Minnesota, District Office.

3. Hendrickson, J.S., and F.R. Haase (1993). Interim Report, Weaver Bottoms Rehabilitation Project Resource Analysis Program. Hydrodynamic Impacts, Appendix B.

4. Kalio, N.A. (1966). Effect of Vertical Motion on Current Meters. U.S. Geological Survey Water Supply Paper 1869-B.

APPENDIX

Discharge Measurements Obtained in Pool 8 of the Upper Mississippi River, 1987-93.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 1 - RAFT CHANNEL CLOSEST TO MN. R.M. 687.4 W 3000' (FLOW IS N TO S FROM NAVIGATION CHANNEL)				
	9/23/87	COE	20400	2581	12.65%
	4/24/89	USGS	53630	4430	8.26%
*	3/27/90	COE	43960	4051	9.22%
*	4/30/92	COE	88400	6661	7.54%
**	4/21/93	COE	116400	8545	7.34%
**	5/03/93	COE	81850	6938	8.48%
**	6/14/93	BARR	79800	7690	9.64%
**	8/07/93	BARR	72100	5821	8.07%
**	9/22/93	BARR	47950	4369	9.11%
**	11/04/93	BARR	27500	2796	10.17%
	SITE 2 - RAFT CHANNEL - MIDDLE CHANNEL, R.M. 687.5 W 2000' (FLOW IS N TO S FROM NAVIGATION CHANNEL)				
	9/23/87	COE	20400	2097	10.28%
	4/25/89	USGS	52070	3570	6.86%
*	3/27/90	COE	44700	2899	6.49%
*	4/30/92	COE	89000	6115	6.87%
**	4/21/93	COE	116400	8716	7.49%
**	5/04/93	COE	81925	5968	7.28%
**	6/14/93	BARR	79525	6735	8.47%
**	8/07/93	BARR	72100	4992	6.92%
**	9/23/93	BARR	47400	3335	7.04%
**	11/04/93	BARR	27450	1953	7.11%
	SITE 3 - RAFT CHANNEL CLOSEST TO U-SHAPED ISLAND, R.M. 687.5 W 1200' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
	9/23/87	COE	20400	667	3.27%
	4/25/89	USGS	51080	1290	2.53%
*	3/26/90	COE	50540	753	1.49%
*	4/30/92	COE	89400	1505	1.68%
**	4/21/93	COE	116300	2872	2.47%
**	5/04/93	COE	81900	2007	2.45%
**	6/15/93	BARR	78700	1987	2.52%
**	8/07/93	BARR	72169	1274	1.77%
**	9/23/93	BARR	47350	801	1.69%
**	11/05/93	BARR	28350	533	1.88%

Appendix (Continued.) Summary of Discharge Measurements.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 4 - CUT IN U-SHAPED ISLAND, R.M. 687.5 W 1100' (FLOW IS NW TO SE)				
	9/23/87	COE	20500	111	0.54%
	6/20/89	COE	30050	106	0.35%
	SITE 5 - CUT IN U-SHAPED ISLAND, R.M. 687.4 W 1400' (FLOW IS W TO E)				
	9/24/87	COE	20400	111	0.54%
	6/20/89	COE	30050	0	0.00%
	SITE 6 - NAVIGATION CHANNEL, R.M. 687.5 (FLOW IS NW TO SE)				
	9/24/87	COE	20500	7922	38.64%
	4/25/89	USGS	51950	14990	28.85%
**	4/22/93	COE	117450	17851	15.20%
**	5/05/93	COE	81300	16705	20.55%
**	6/15/93	BARR	78600	20470	26.04%
**	8/07/93	BARR	72275	17578	24.32%
**	9/22/93	BARR	47800	13537	28.32%
**	11/04/93	BARR	27425	9216	33.60%
	SITE 7 - U/S OF TURTLE ISLAND, R.M. 687.1 E 800' (POSITIVE DISCHARGES MEAN FLOW IS NE TO SW TO NAVIGATION CHANNEL)				
	9/24/87	COE	20500	-79	0.39%
*	3/28/90	COE	38300	814	2.13%
**	4/22/93	COE	117400	3013	2.57%
**	5/05/93	COE	81400	131	0.16%
**	6/18/93	BARR	78575	1340	1.71%
**	8/05/93	BARR	72763	-2657	3.65%
**	9/22/93	BARR	47750	-2447	5.12%
**	11/04/93	BARR	27400	-2088	7.62%
	SITE 8 - TURTLE ISLAND TO DAYMARK 686.1, R.M. 686.2 N 500' (FLOW IS N TO S TO NAVIGATION CHANNEL)				
	9/24/87	COE	20500	1422	6.94%
	4/27/89	USGS	48675	3460	7.11%
**	6/18/93	BARR	78812	8355	10.60%
**	8/05/93	BARR	72275	6261	8.66%
**	9/22/93	BARR	47700	3831	8.03%
**	11/03/93	BARR	27425	825	3.01%

Appendix (Continued.) Summary of Discharge Measurements.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 9 - DAYMARK 686.1 TO 685.9, R.M. 686.0 NE 300' (FLOW IS NE TO SW TO NAVIGATION CHANNEL)				
	9/24/87	COE	20500	2441	11.91%
	4/27/89	USGS	48350	6290	13.01%
**	6/17/93	BARR	77062	12196	15.83%
**	8/05/93	BARR	72400	5886	8.13%
**	9/22/93	BARR	47600	3844	8.08%
**	11/03/93	BARR	27575	55	0.20%
	SITE 10 - CROSBY SLOUGH, R.M. 685.8 NE 1000' (FLOW IS N TO S TO NAVIGATION CHANNEL)				
	9/25/87	COE	20400	4627	22.68%
	4/27/89	USGS	48130	5520	11.47%
**	6/17/93	BARR	77675	18003	23.18%
**	8/06/93	BARR	73008	15753	21.58%
**	9/22/93	BARR	48400	10445	21.58%
**	11/03/93	BARR	27450	5698	20.76%
	SITE 8/9/10, R.M. 686.0 NE 600' (FLOW IS N TO S TO NAVIGATION CHANNEL) (INCLUDES SINGLE MEASUREMENT AT THIS SITE ALONG WITH SUMMATION OF MEASUREMENTS AT SITES 8,9,&10)				
	9/24/87	COE	20466	8490	41.48%
	4/27/89	USGS	48385	15270	31.56%
*	3/28/90	COE	38500	15922	41.36%
**	4/22/93	COE	117000	45682	39.04%
**	5/05/93	COE	81800	40277	49.24%
**	6/17&18/93	BARR	77850	38554	49.52%
**	8/05&06/93	BARR	72560	27900	38.45%
**	9/22/93	BARR	47900	18120	37.83%
**	11/03/93	BARR	27480	6578	23.94%
	SITE 11 - U/S OF STODDARD, R.M. 687.5 E 11000' (FLOW IS NE TO SW)				
	9/25/87	COE	20400	604	2.96%
	4/29/89	USGS	45860	421	0.92%
**	6/16/93	BARR	75725	2734	3.61%
**	8/05/93	BARR	74900	2144	2.86%
**	9/21/93	BARR	51200	1371	2.68%
**	11/03/93	BARR	27675	661	2.39%

Appendix (Continued.) Summary of Discharge Measurements.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 12 - U/S OF STODDARD, R.M. 687.7 E 11000' (FLOW IS N TO S)				
	9/25/87	COE	20400	235	1.15%
	4/29/89	USGS	45830	796	1.74%
**	6/17/93	BARR	78175	2271	2.91%
**	8/05/93	BARR	74025	2115	2.86%
**	9/22/93	BARR	49200	931	1.89%
**	11/03/93	BARR	27375	485	1.77%
	SITE 11/12, R.M. 687.6 E 11000' (FLOW IS NE TO SW) (INCLUDES SINGLE MEASUREMENT AT THIS SITE ALONG WITH SUMMATION OF MEASUREMENTS AT SITES 11&12)				
	9/25/87	COE	20400	839	4.11%
	4/29/89	USGS	45845	1217	2.65%
**	5/05/93	COE	81300	8542	10.51%
**	6/16&17/93	BARR	76950	5005	6.50%
**	8/05/93	BARR	74462	4259	5.72%
**	9/21&22/93	BARR	50200	2302	4.59%
**	11/03/93	BARR	27525	1146	4.16%
	SITE 13 - R.M. 687.0 W 600' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
	4/26/89	USGS	51600	178	0.34%
	6/21/89	COE	28900	0	0.00%
*	3/26/90	COE	51500	186	0.36%
*	7/16/91	COE	51400	220	0.43%
*	4/29/92	COE	91800	1748	1.90%
	SITE 14 - BENOVER SLOUGH, R.M. 686.8 S 800' (FLOW IS NW TO SE FROM NAVIGATION CHANNEL) (SEE SITE 28 FOR POST PHASE 1 CONDITIONS.)				
	4/26/89	USGS	51306	743	1.45%
	6/21/89	COE	28600	229	0.80%
*	3/27/90	COE	41800	716	1.71%
*	7/11/90	COE	45150	747	1.65%
*	7/16/91	COE	51400	680	1.32%
*	4/29/92	COE	92000	1842	2.00%

Appendix (Continued.) Summary of Discharge Measurements.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 15 - DEADMANS SLOUGH, R.M. 686.5 S 800' (FLOW IS NW TO SE FROM NAVIGATION CHANNEL)				
*	7/11/90	COE	45000	1295	2.88%
	SITE 16 - N.W. OF GRASSY ISLAND, R.M. 685.2 W 2000' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
*	7/11/90	COE	48600	500	1.03%
	SITE 17 - MIDDLE SLOUGH, R.M. 684.6 W 1000' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
	4/30/89	USGS	46030	1900	4.13%
	SITE 18 - NAVIGATION CHANNEL, R.M. 683.3 (FLOW IS N TO S)				
	4/30/89	USGS	46020	12310	26.75%
	SITE 19 - NAVIGATION CHANNEL, R.M. 691.6 (FLOW IS NE TO SW)				
	4/28/89	USGS	46250	33840	73.17%
	SITE 20 - R.M. 685.8 W 3000' (FLOW IS N TO S FROM NAVIGATION CHANNEL)				
*	5/08/91	COE	75750	6138	8.10%
*	4/28/92	COE	93200	10429	11.19%
	SITE 21 - R.M. 685.8 W 1500' (FLOW IS N TO S)				
*	5/08/91	COE	75750	3256	4.30%
*	4/29/92	COE	92800	5161	5.56%
	SITE 22 - R.M. 685.5 W 2000' (POSITIVE DISCHARGE MEANS FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
*	5/09/91	COE	80000	659	0.82%
*	4/28/92	COE	93450	-278	0.30%

Appendix (Continued.) Summary of Discharge Measurements.

	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 23 - N.W. OF GRASSY ISLAND, R.M. 685.3 W 1500' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
*	5/09/91	COE	78700	841	1.07%
*	4/28/92	COE	93450	1242	1.33%
**	4/21/93	COE	116150	5689	4.90%
**	5/04/93	COE	81750	3694	4.52%
**	6/15/93	BARR	78250	2556	3.27%
**	8/06/93	BARR	72788	2554	3.51%
**	9/23/93	BARR	47200	1711	3.63%
**	11/04/93	BARR	27425	689	2.51%
	SITE 24 - GRASSY ISLAND TO TRAPPING ISLAND, R.M. 685.1 W 1000' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
*	5/09/91	COE	81000	6821	8.42%
*	4/29/92	COE	92400	8881	9.61%
**	4/22/93	COE	117250	14069	12.00%
**	5/04/93	COE	81700	10271	12.57%
**	6/16/93	BARR	75600	7713	10.20%
**	8/06/93	BARR	72725	5866	8.07%
**	9/23/93	BARR	47550	3810	8.01%
**	11/04/93	BARR	27450	1927	7.02%
	SITE 25 - TRAPPING ISLAND TO HERON ISLAND, R.M. 685.0 W 400' (FLOW IS NE TO SW FROM NAVIGATION CHANNEL)				
*	5/09/91	COE	81350	3359	4.13%
*	4/29/92	COE	92400	4185	4.53%
**	4/22/93	COE	117300	6540	5.58%
**	5/04/93	COE	81650	4957	6.07%
**	6/16/93	BARR	75662	4790	6.33%
**	8/06/93	BARR	72675	4413	6.07%
**	9/23/93	BARR	47900	2490	5.20%
**	11/04/93	BARR	27475	1331	4.84%
	SITE 26 - STODDARD BAY, R.M. 685.9 E 3500' (FLOW IS N TO S)				
*	4/29/92	COE	92400	16199	17.53%
**	4/22/93	COE	117100	22926	19.58%
**	5/05/93	COE	82150	14487	17.63%
**	6/17/93	BARR	78900	13094	16.60%
**	8/06/93	BARR	72804	8123	11.16%
**	9/21/93	BARR	51200	5335	10.42%
**	11/03/93	BARR	28750	3138	10.91%

Appendix (Continued.) Summary of Discharge Measurements.

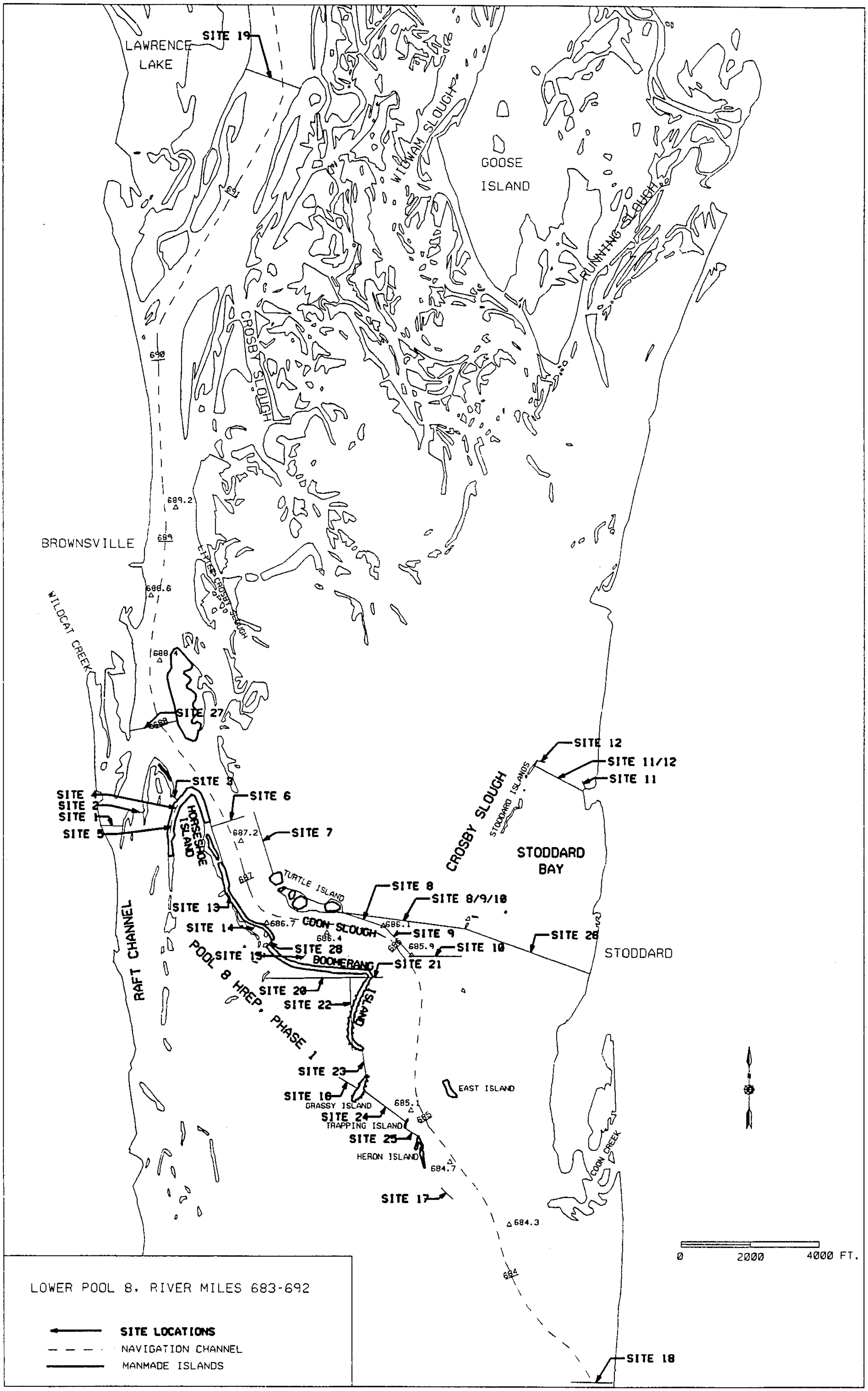
	DATE	SOURCE OF DATA	L&D 8 Q	SITE Q	PERCENT OF L&D 8 Q
	SITE 27 - NAVIGATION CHANNEL, R.M. 688.0 (FLOW IS NW TO SE)				
*	4/28/92	COE	94000	38196	40.63%
	SITE 28 - OPENING IN PHASE II ISLAND, R.M. 686.7 SW 100' (FLOW IS E TO W)				
**	4/21/93	COE	115650	2565	2.22%
**	5/04/93	COE	81850	1804	2.20%
**	6/02/93	COE	77625	1517	1.95%
**	6/15/93	BARR	78350	1504	1.92%
**	8/06/93	BARR	72575	1153	1.59%
**	9/23/93	BARR	47300	696	1.47%
**	11/05/93	BARR	29050	647	2.23%

DATE	SOURCE OF DATA	L&D 7 Q	SITE Q	PERCENT OF L&D 7 Q
EAST CHANNEL INLET, R.M. 701.7 E 700' (FLOW IS W TO E FROM NAVIGATION CHANNEL)				
7/16/92	COE	56600	5427	9.59%
8/28/92	COE	17350	680	3.92%
9/08/92	COE	29700	2264	7.62%
9/24/92	COE	39450	2338	5.93%
6/03/93	COE	77595	10586	13.64%
EAST CHANNEL INLET, R.M. 701.4 E 900' (FLOW IS W TO E FROM NAVIGATION CHANNEL)				
7/16/92	COE	56600	4065	7.18%
8/28/92	COE	17125	537	3.14%
9/08/92	COE	29675	1410	4.75%
9/24/92	COE	38625	1511	3.91%
6/03/93	COE	77837	7110	9.13%
EAST CHANNEL INLET, R.M. 700.5 NE 500' (FLOW IS SW TO NE FROM NAVIGATION CHANNEL)				
7/16/92	COE	56500	234	0.41%
8/28/92	COE	17675	32	0.18%
9/08/92	COE	29750	102	0.34%
9/24/92	COE	38225	133	0.35%
6/03/92	COE	78000	703	0.90%

Appendix (Continued.) Summary of Discharge Measurements.

DATE	SOURCE OF DATA	L&D 7 Q	SITE Q	PERCENT OF L&D 7 Q
SMITH SLOUGH, R.M. 700.4 NE 2900' (upstream end) (FLOW IS W TO E)				
7/16/92	COE	56650	845	1.49%
8/28/92	COE	17675	28	0.16%
9/08/92	COE	29800	135	0.45%
6/03/93	COE	76763	2036	2.65%
SMITH SLOUGH, R.M. 700.3 NE 5500' (downstream end) (FLOW IS SW TO NE)				
6/03/93	COE	77388	971	1.25%
FRENCH SLOUGH, R.M. 700.2 NE 6300' (FLOW IS NW TO SE)				
7/16/92	COE	56550	962	1.70%
8/24/92	COE	18500	360	1.95%
9/08/92	COE	29800	307	1.03%
6/03/93	COE	77700	2700	3.47%
WEST CHANNEL, R.M. 699.0 SW 2000' (FLOW IS N TO S)				
6/03/93	COE	77962	15078	19.34%
ONALASKA SPILLWAY, BLACK RIVER R.M. 4.8 (FLOW IS NE TO SW)				
7/16/93	COE	56250	1410	2.51%
8/24/92	COE	18500	1650	8.92%
9/08/92	COE	29900	1574	5.26%
9/21/92	COE	65475	1322	2.02%
10/05/92	COE	19900	1392	6.99%
6/01/93	COE	69925	1269	1.81%
7/28/93	COE	77700	1461	1.88%
BLACK RIVER, BLACK RIVER R.M. 0.7 (FLOW IS N TO S)				
8/04/87	WDNR	30900	1410	4.56%

Note 1: * Indicates measurements taken Post Phase 1 Stage 1.
Note 2: ** Indicates measurements taken Post Phase 1 Stage 2.



LAWRENCE LAKE
SITE 19
GOOSE ISLAND
WIGWAM SLOUGH
RUNNING SLOUGH
CROSBY SLOUGH
BROWNSVILLE
WILDCAT CREEK
SITE 27
SITE 12
SITE 11/12
SITE 11
SITE 3
SITE 4
SITE 2
SITE 1
SITE 5
SITE 6
SITE 7
HORSESHOE ISLAND
CROSBY SLOUGH
STODDARD ISLANDS
STODDARD BAY
TURTLE ISLAND
SITE 8
SITE 8/9/10
COON SLOUGH
SITE 13
SITE 14
SITE 9
SITE 26
SITE 28
SITE 15
SITE 10
STODDARD
BOOMERANG ISLAND
SITE 21
RAFT CHANNEL
POOL 8 HREP, PHASE 1
SITE 20
SITE 22
SITE 23
SITE 16
GRASSY ISLAND
SITE 24
TRAPPING ISLAND
SITE 25
HERON ISLAND
EAST ISLAND
COON CREEK
SITE 17
SITE 18
0 2000 4000 FT.
LOWER POOL 8, RIVER MILES 683-692
SITE LOCATIONS
NAVIGATION CHANNEL
MANMADE ISLANDS

Figure 1

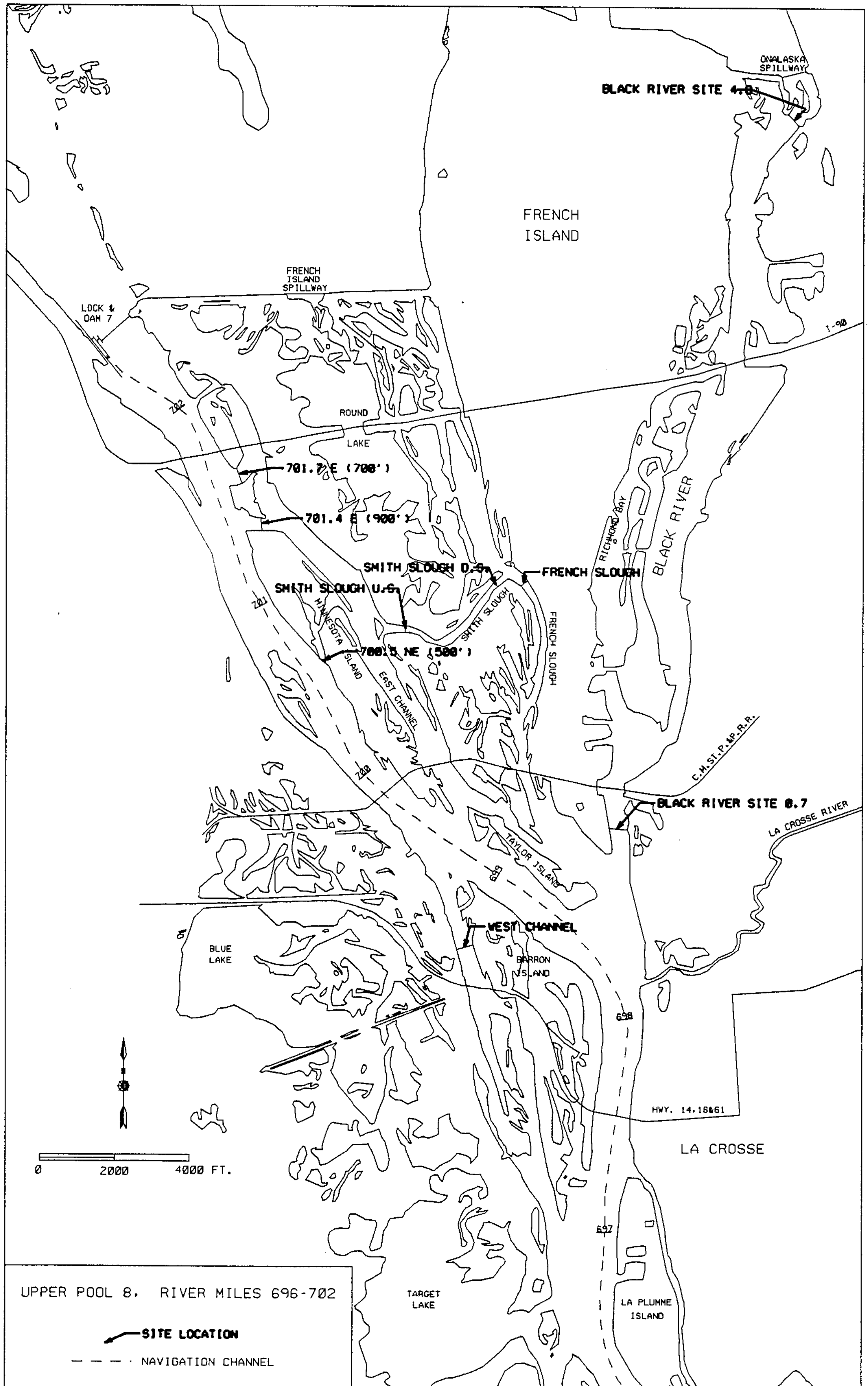
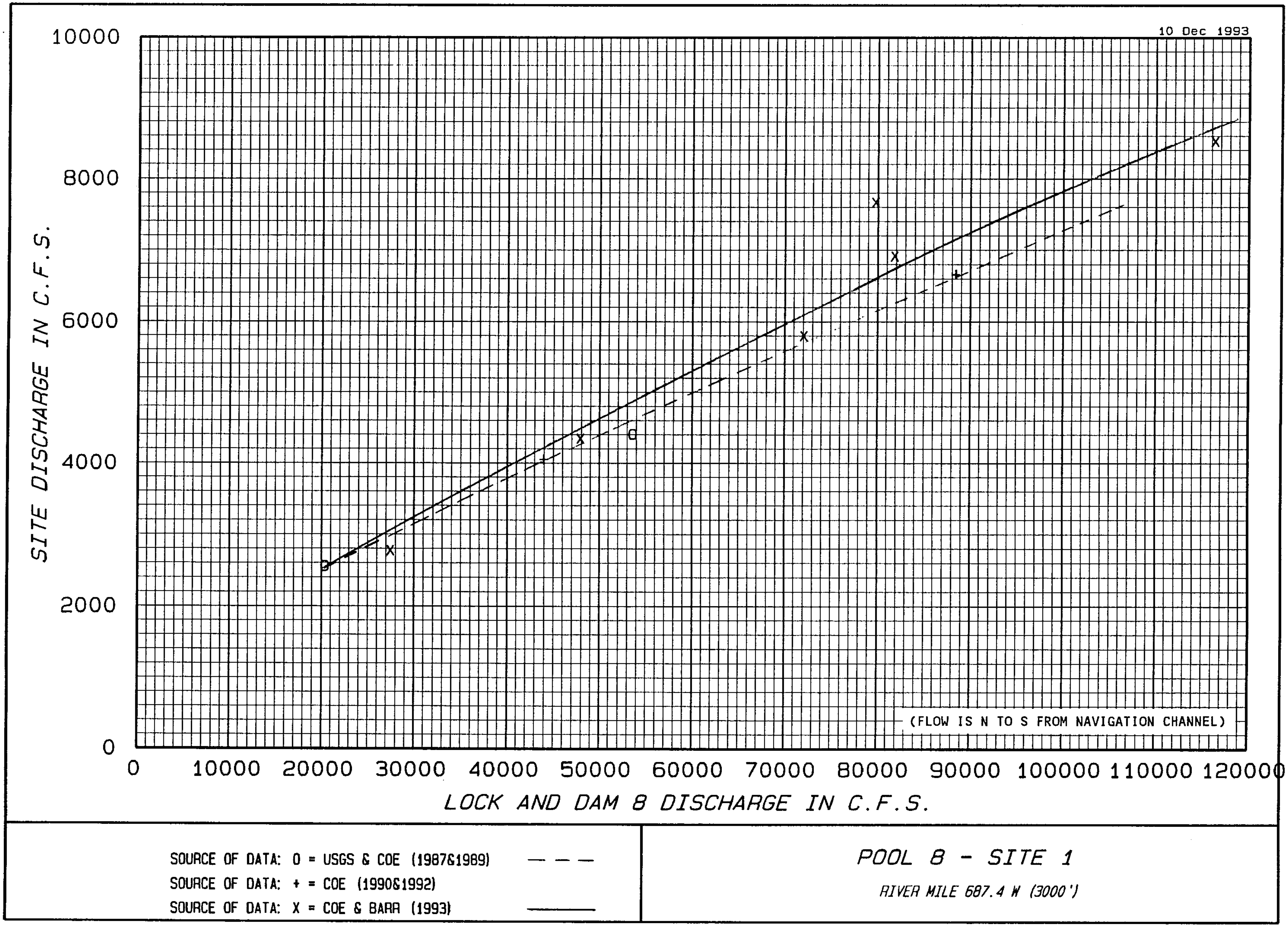

ONALASKA SPILLWAY
BLACK RIVER SITE 4.0
FRENCH ISLAND
FRENCH ISLAND SPILLWAY
LOCK & DAM 7
I-90
ROUND LAKE
702
701.7 E (700')
701.4 E (900')
RICHMOND BAY
BLACK RIVER
SMITH SLOUGH D.S.
FRENCH SLOUGH
SMITH SLOUGH U.S.
701
MINNESOTA ISLAND
SMITH SLOUGH
FRENCH SLOUGH
700.5 NE (500')
EAST CHANNEL
C.M.ST.P.&P.R.R.
700
BLACK RIVER SITE 0.7
LA CROSSE RIVER
TAYLOR ISLAND
699
WEST CHANNEL
BLUE LAKE
BARRON ISLAND
698
HWY. 14,16&61
LA CROSSE
0
2000
4000 FT.
697
UPPER POOL 8, RIVER MILES 696-702
SITE LOCATION
NAVIGATION CHANNEL
TARGET LAKE
LA PLUMME ISLAND
696

Figure 2



10 Dec 1993
SITE DISCHARGE IN C.F.S.
10000
8000
6000
4000
2000
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS N TO S FROM NAVIGATION CHANNEL)
SOURCE OF DATA: O = USGS & COE (1987&1989)
SOURCE OF DATA: + = COE (1990&1992)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 1
RIVER MILE 687.4 W (3000')

Figure 3

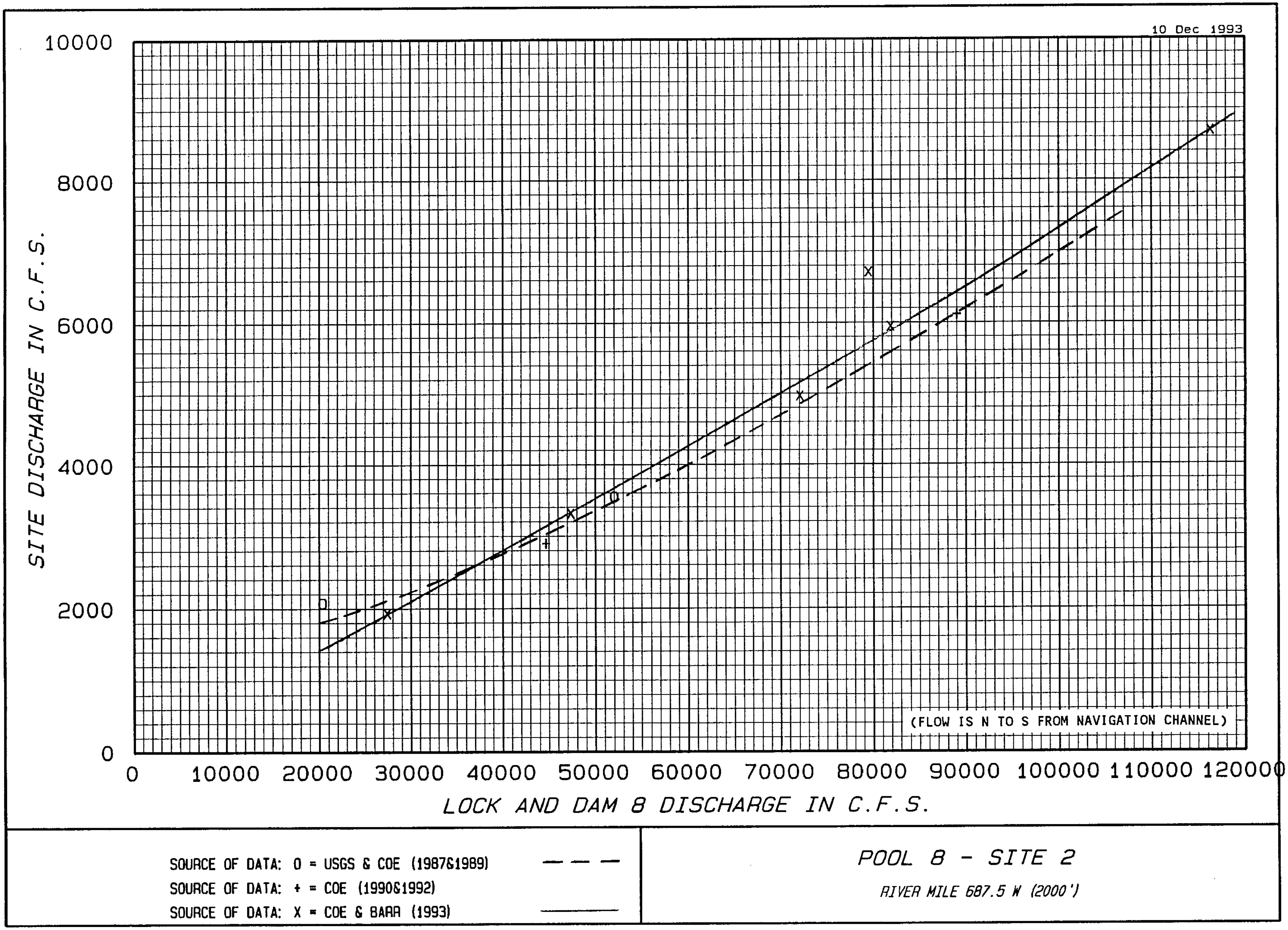
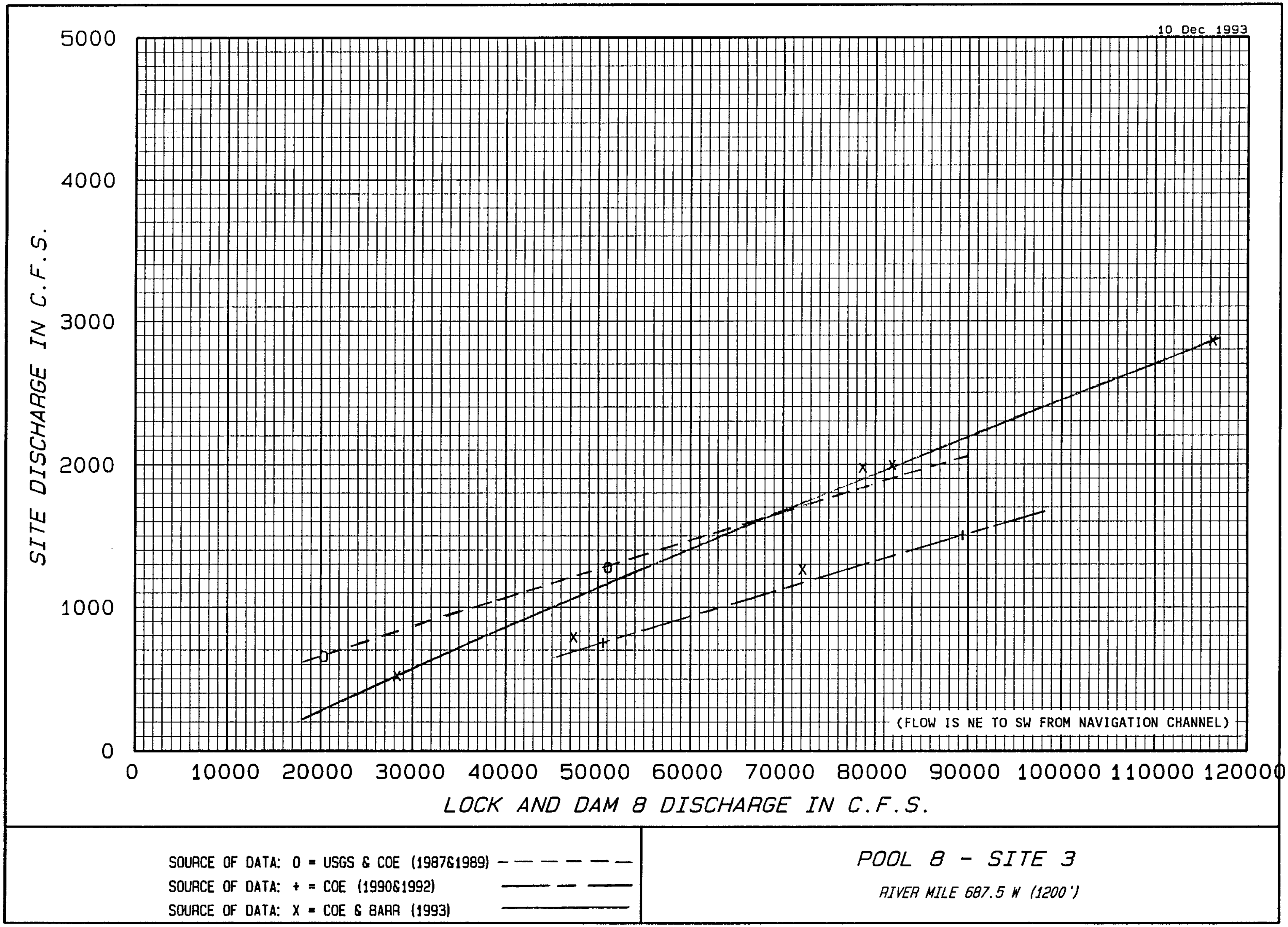

10 Dec 1993
10000
8000
6000
4000
2000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS N TO S FROM NAVIGATION CHANNEL)
SOURCE OF DATA: O = USGS & COE (1987&1989)
SOURCE OF DATA: + = COE (1990&1992)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 2
RIVER MILE 687.5 W (2000')

Figure 4



10 Dec 1993
SITE DISCHARGE IN C.F.S.
5000
4000
3000
2000
1000
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
LOCK AND DAM 8 DISCHARGE IN C.F.S.
SOURCE OF DATA: 0 = USGS & COE (1987&1989)
SOURCE OF DATA: + = COE (1990&1992)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 3
RIVER MILE 687.5 W (1200')

Figure 5

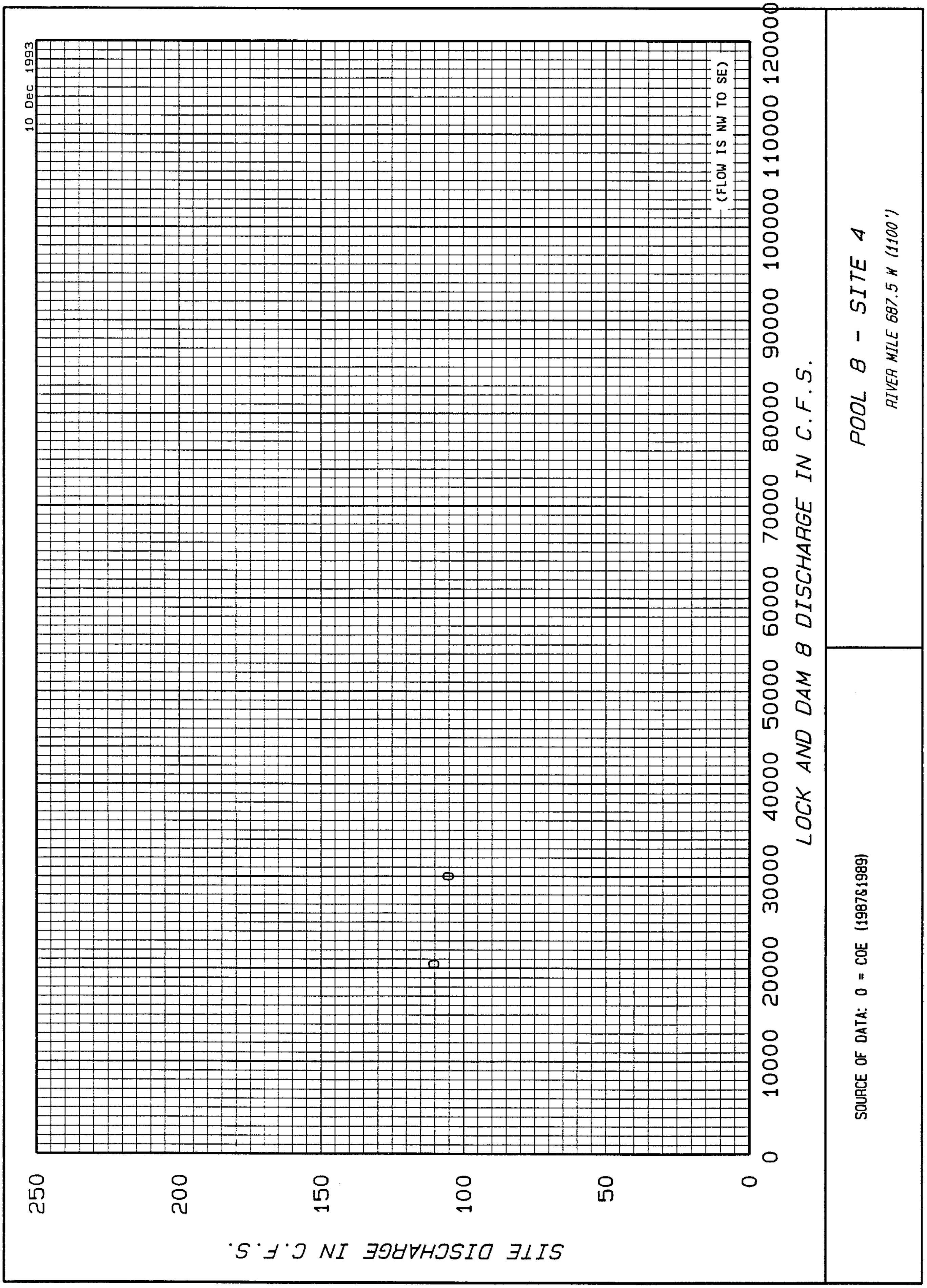

10 Dec 1993
(FLOW IS NW TO SE)
SITE DISCHARGE IN C.F.S.
0
50
100
150
200
250
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
SOURCE OF DATA: O = COE (1987&1989)
POOL 8 - SITE 4
RIVER MILE 687.5 W (1100')

Figure 6

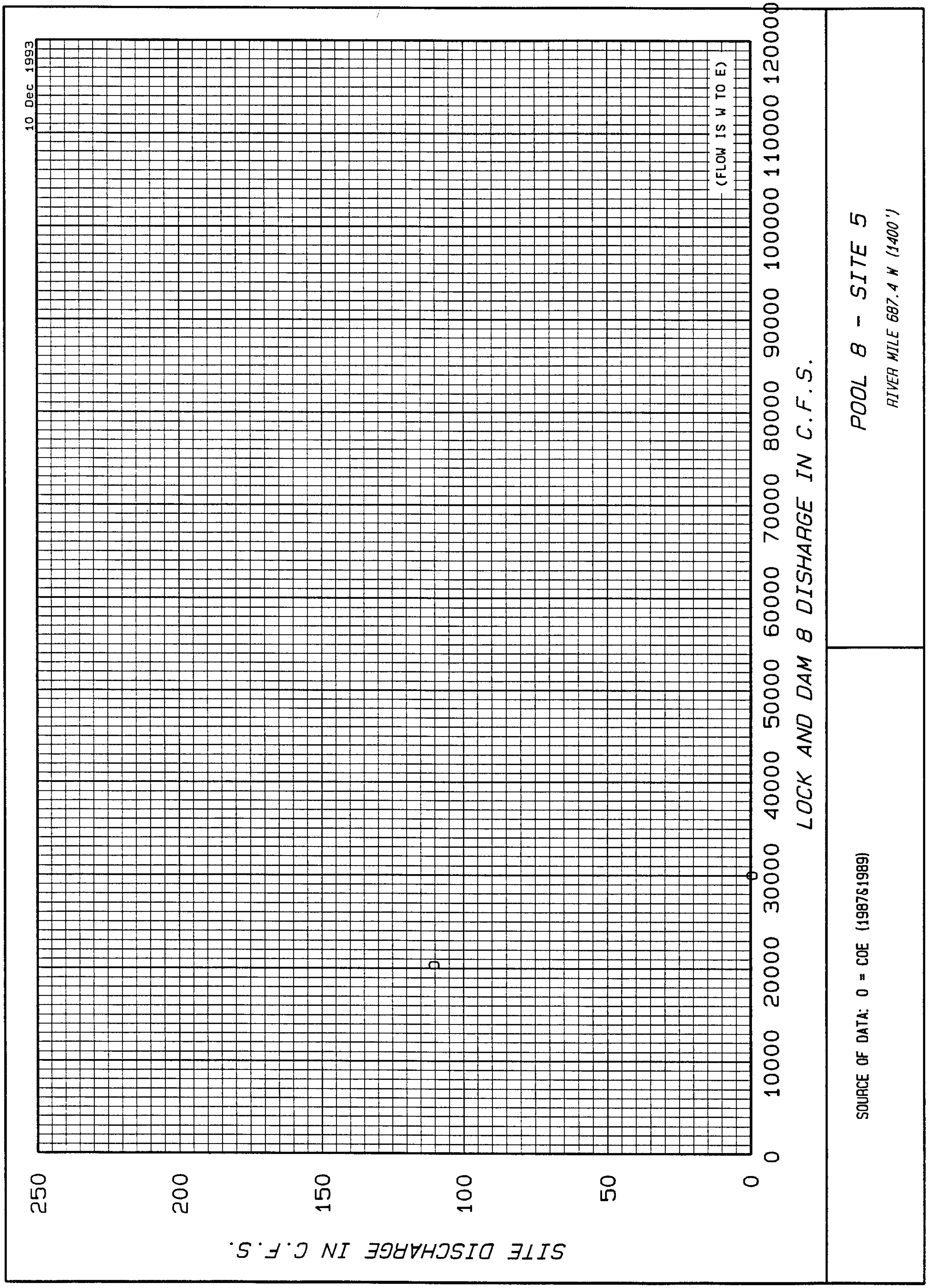

10 Dec 1993
(FLOW IS W TO E)
LOCK AND DAM 8 DISHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
SITE DISCHARGE IN C.F.S.
0
50
100
150
200
250
POOL 8 - SITE 5
RIVER MILE 687.4 W (1400')
SOURCE OF DATA: O = COE (1987&1989)

Figure 7

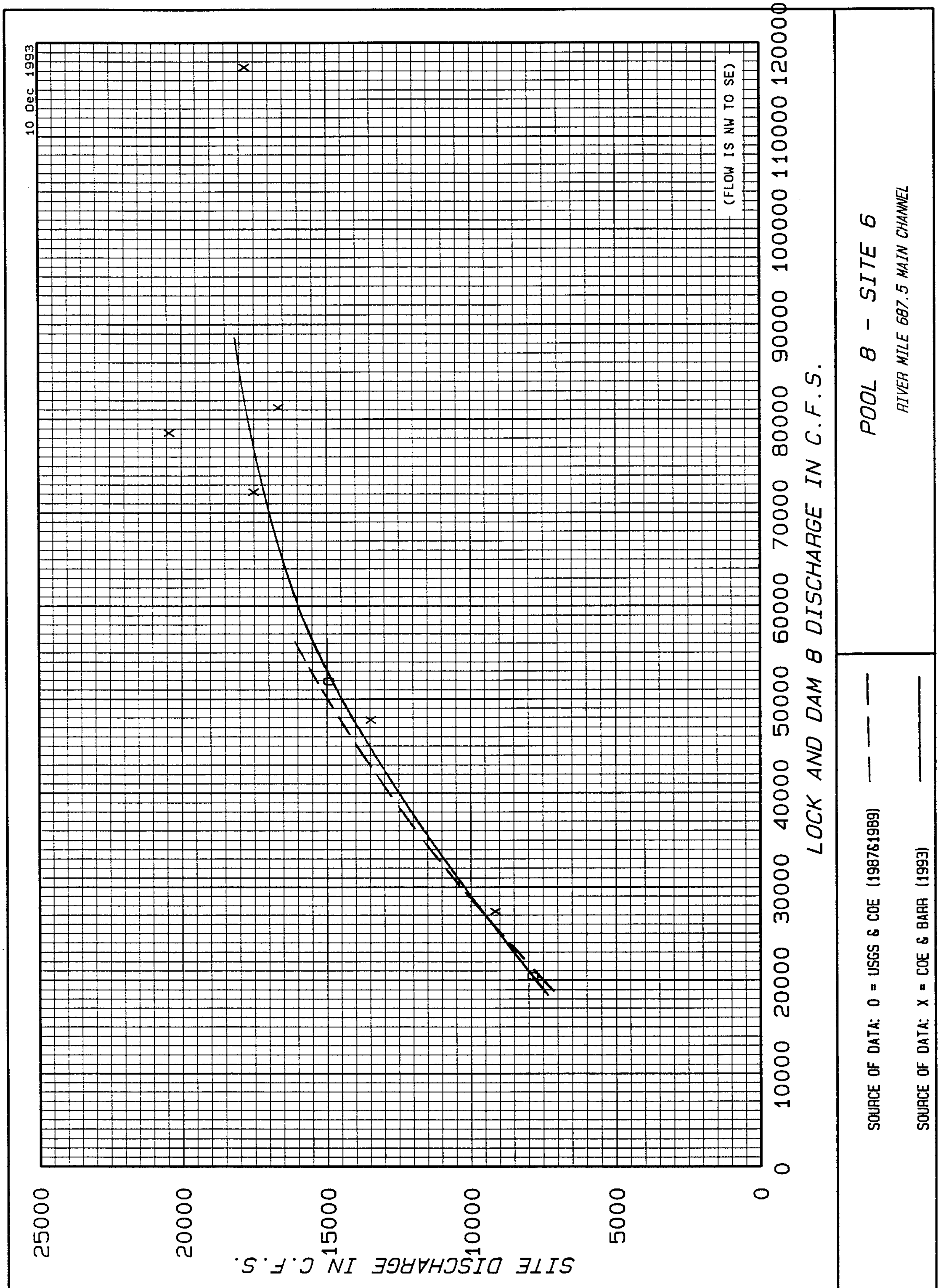
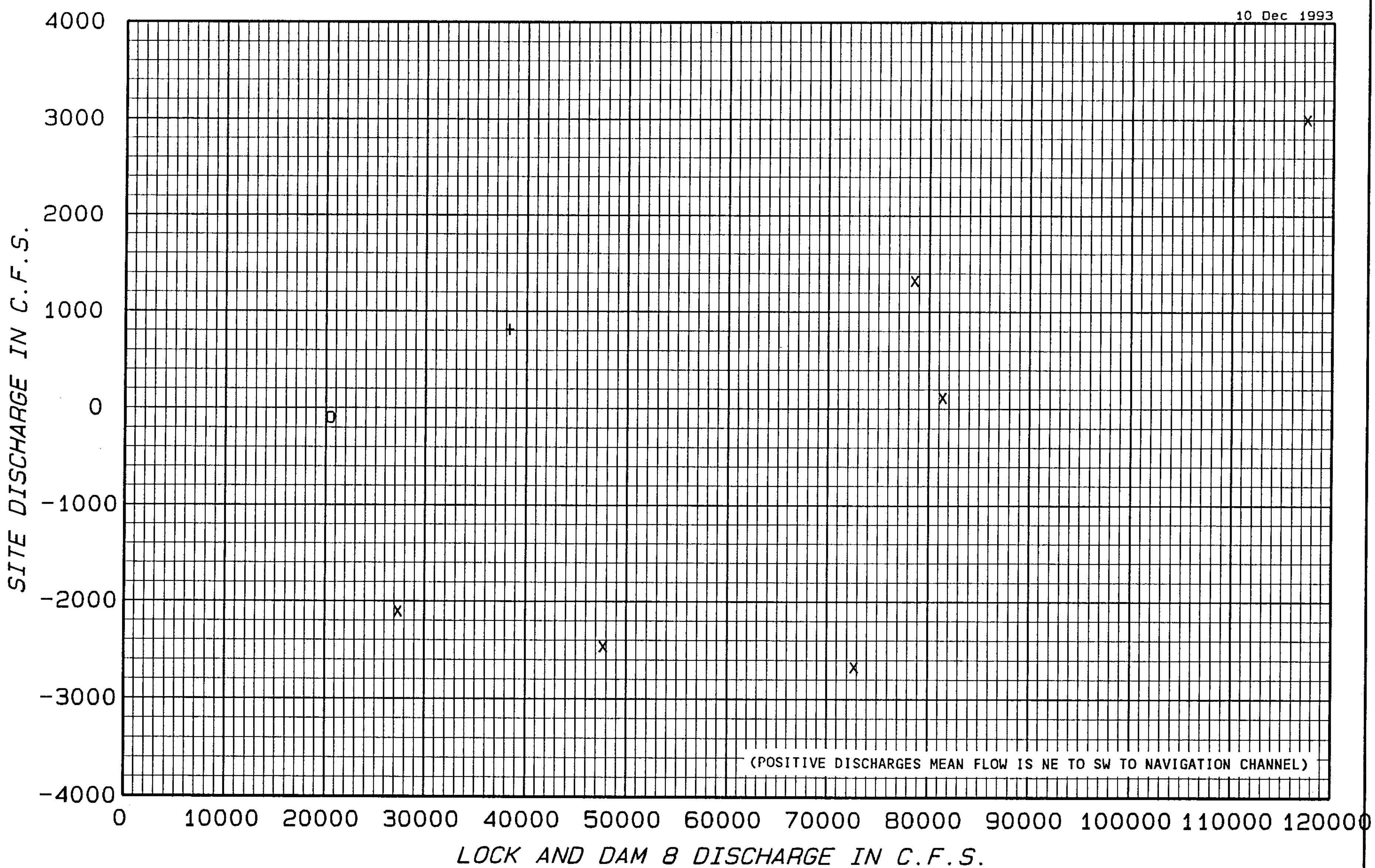

10 Dec 1993
(FLOW IS NW TO SE)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
0
5000
10000
15000
20000
25000
SITE DISCHARGE IN C.F.S.
POOL 8 - SITE 6
RIVER MILE 687.5 MAIN CHANNEL
SOURCE OF DATA: O = USGS & COE (1987&1989)
SOURCE OF DATA: X = COE & BARR (1993)

Figure 8



SOURCE OF DATA: 0 = COE (1987)
SOURCE OF DATA: + = COE (1990)
SOURCE OF DATA: X = COE & BARR (1993)

POOL 8 - SITE 7

RIVER MILE 687.1 E (800') - NEGATIVE NUMBERS = FLOW FROM MAIN CHANNEL

Figure 9

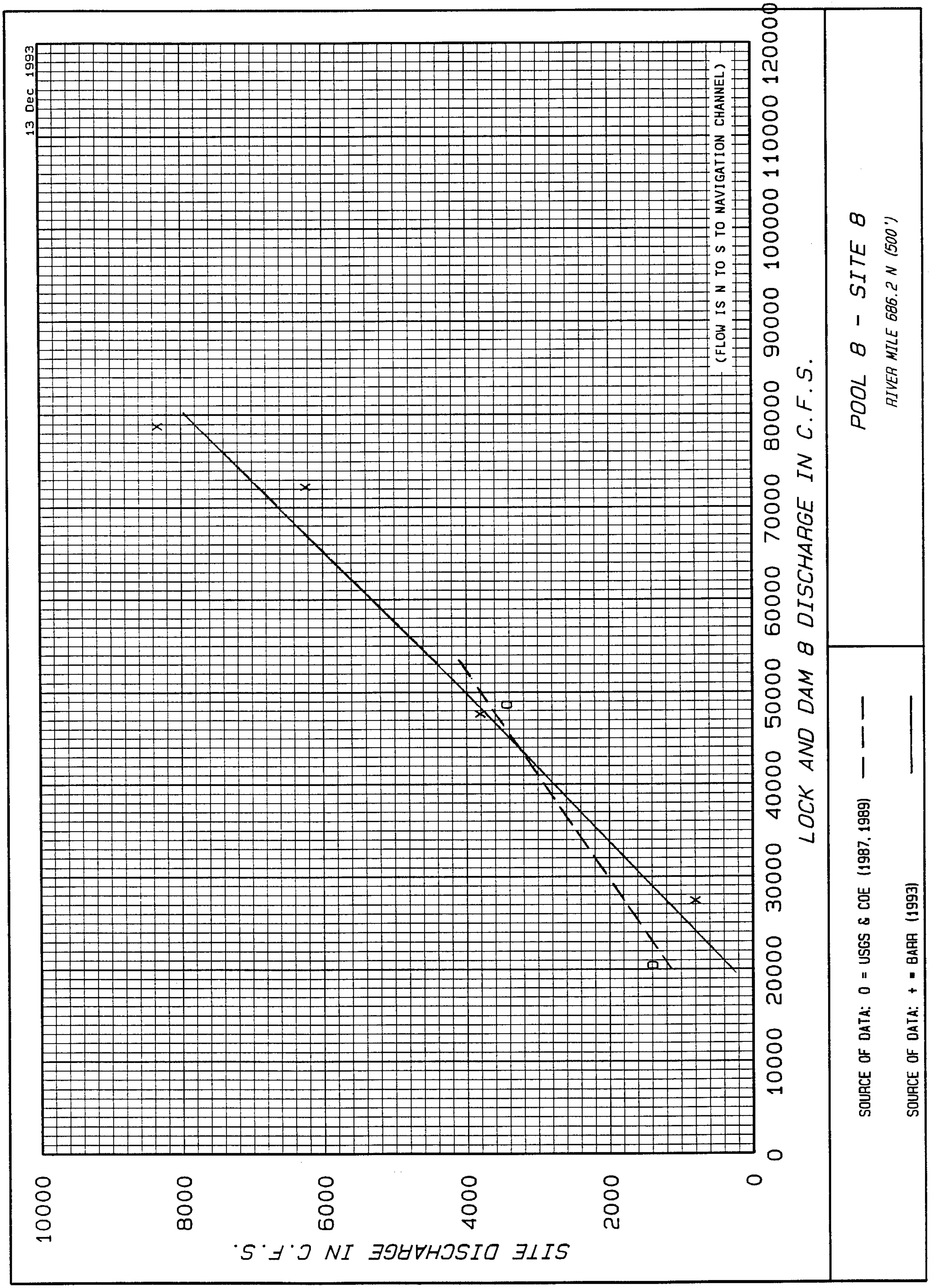

13 Dec 1993
(FLOW IS N TO S TO NAVIGATION CHANNEL)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
0
2000
4000
6000
8000
10000
SITE DISCHARGE IN C.F.S.
POOL 8 - SITE 8
RIVER MILE 686.2 N (500')
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: + = BARR (1993)

Figure 10

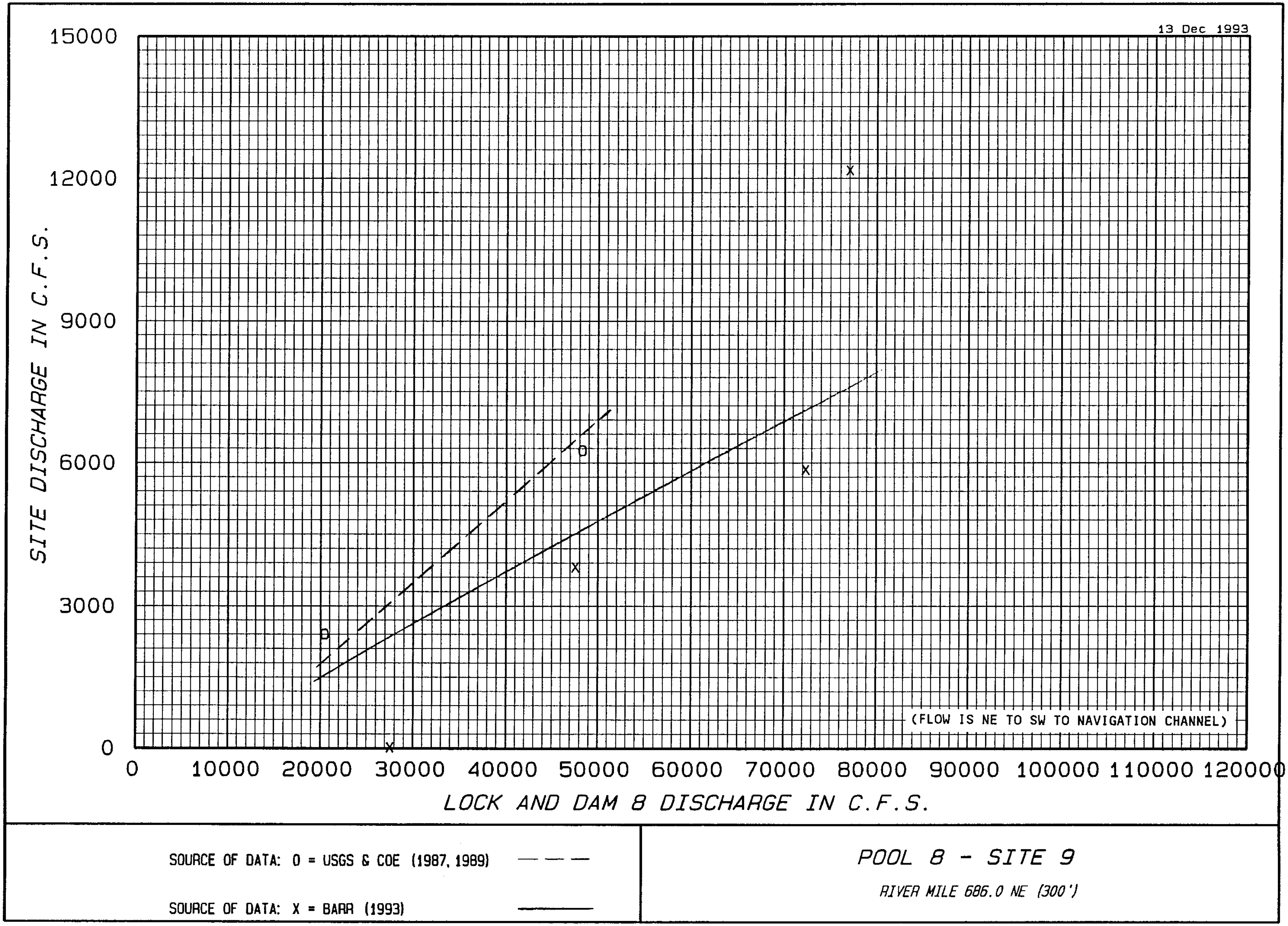

13 Dec 1993
15000
12000
9000
6000
3000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NE TO SW TO NAVIGATION CHANNEL)
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: X = BARR (1993)
POOL 8 - SITE 9
RIVER MILE 686.0 NE (300')

Figure 11

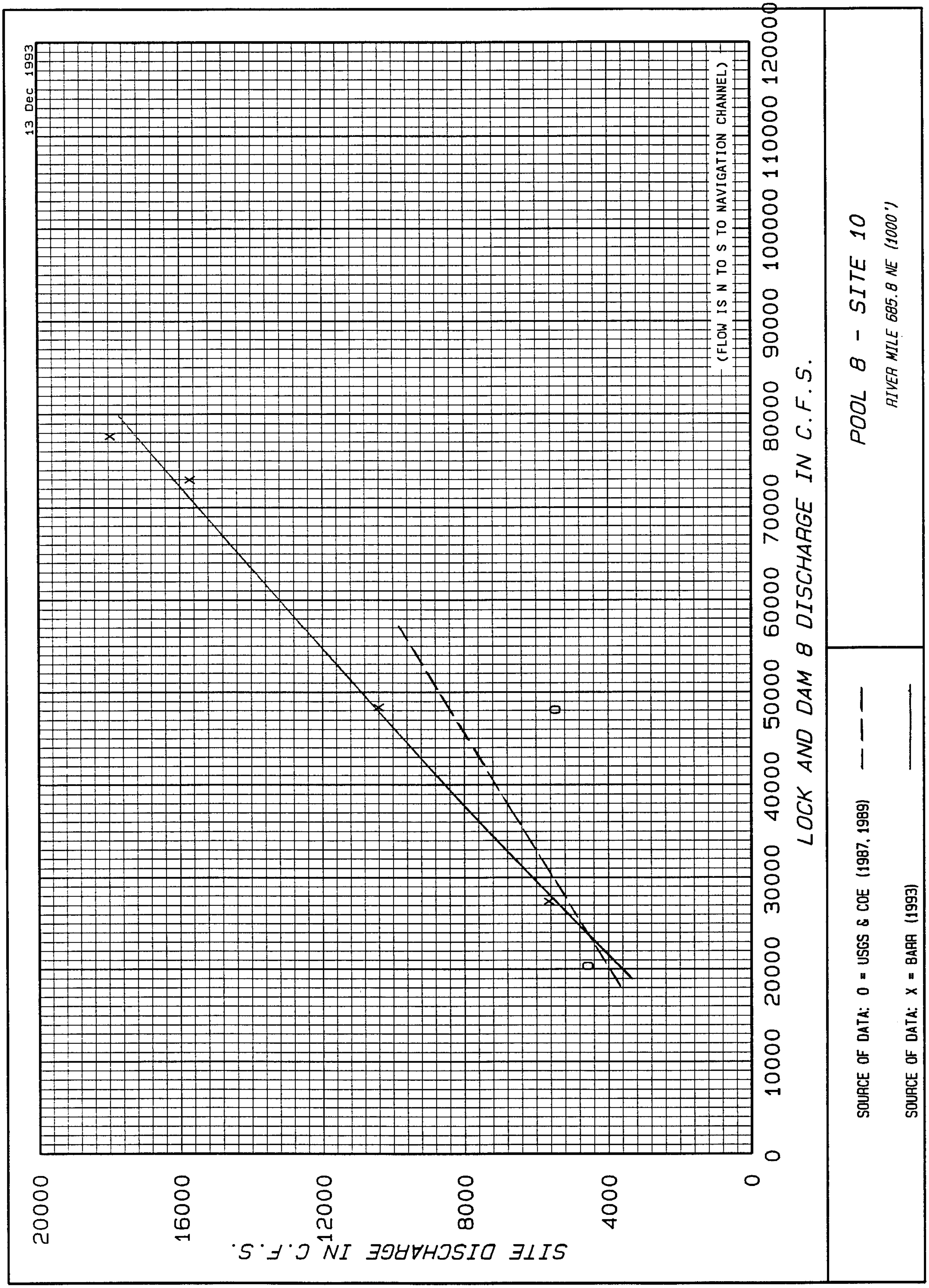

13 Dec 1993
(FLOW IS N TO S TO NAVIGATION CHANNEL)
SITE DISCHARGE IN C.F.S.
20000
16000
12000
8000
4000
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
POOL 8 - SITE 10
RIVER MILE 685.8 NE (1000')
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: X = BARR (1993)

Figure 12

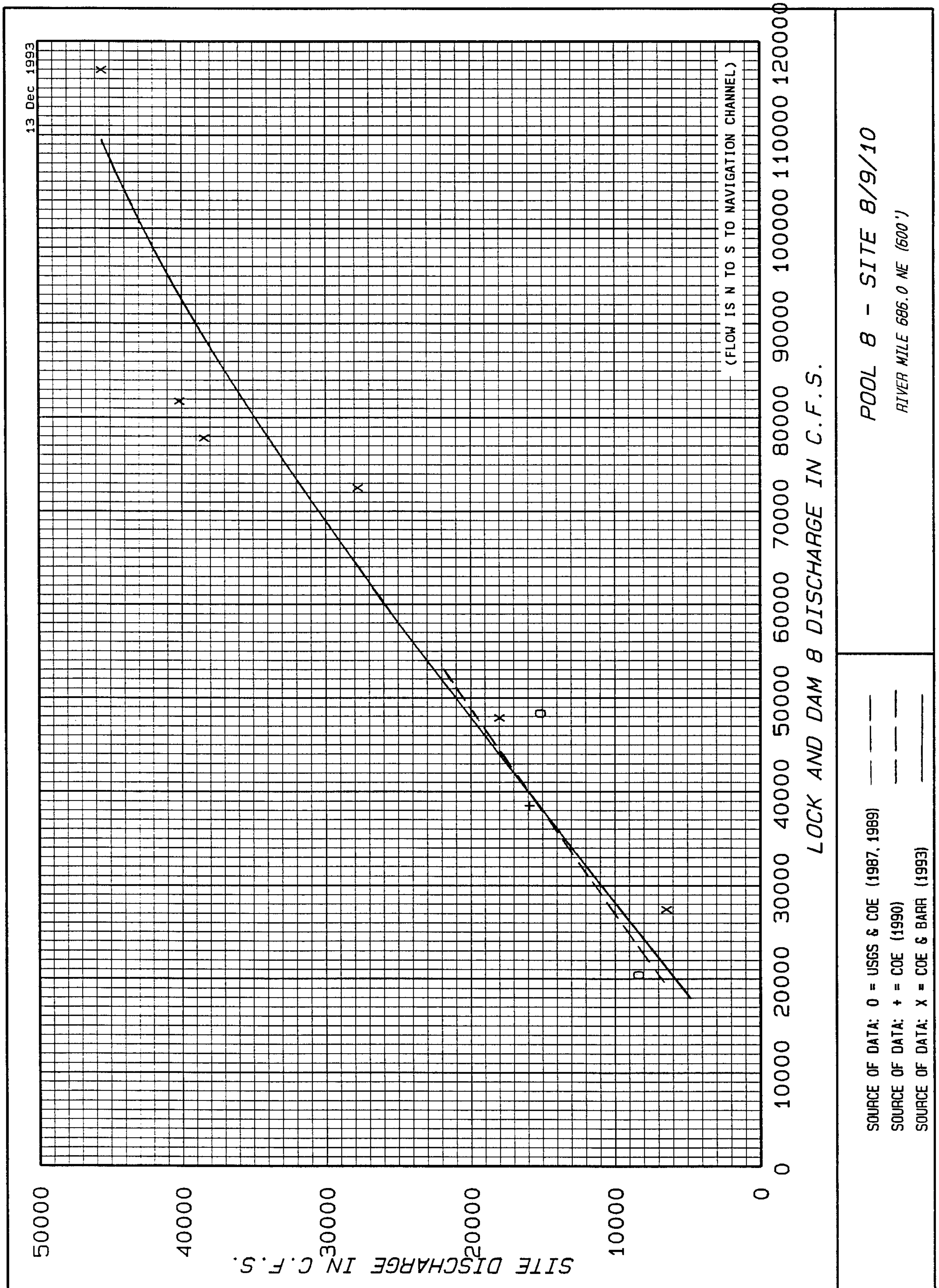
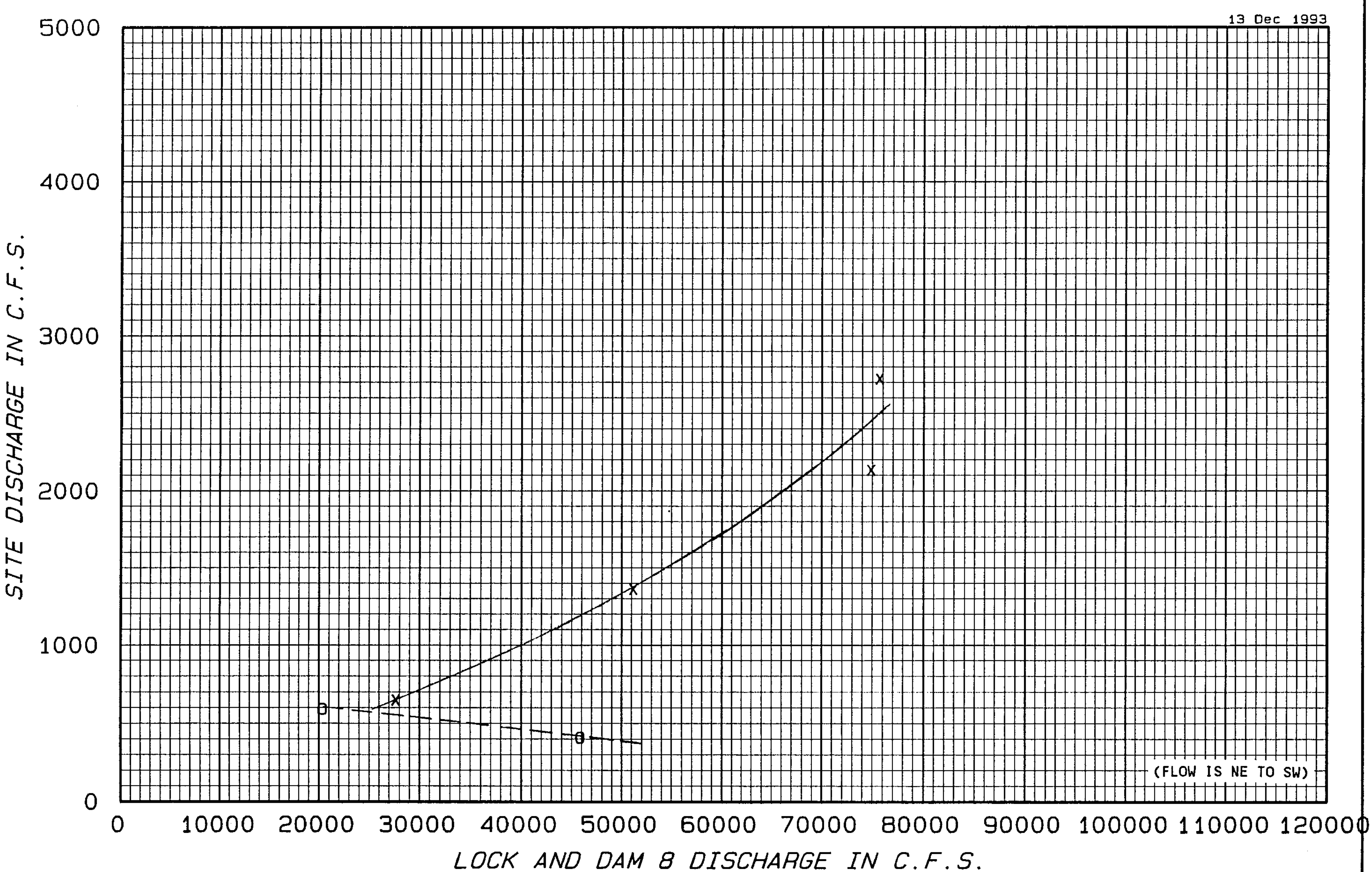

13 Dec 1993
(FLOW IS N TO S TO NAVIGATION CHANNEL)
LOCK AND DAM 8 DISCHARGE IN C.F.S.
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
POOL 8 - SITE 8/9/10
RIVER MILE 686.0 NE (600')
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: + = COE (1990)
SOURCE OF DATA: X = COE & BARR (1993)

Figure 13



SOURCE OF DATA: O = USGS & COE (1987&1989) — — —

SOURCE OF DATA: X = BARR (1993) ———

POOL 8 - SITE 11

RIVER MILE 687.5 E (11000')

Figure 14

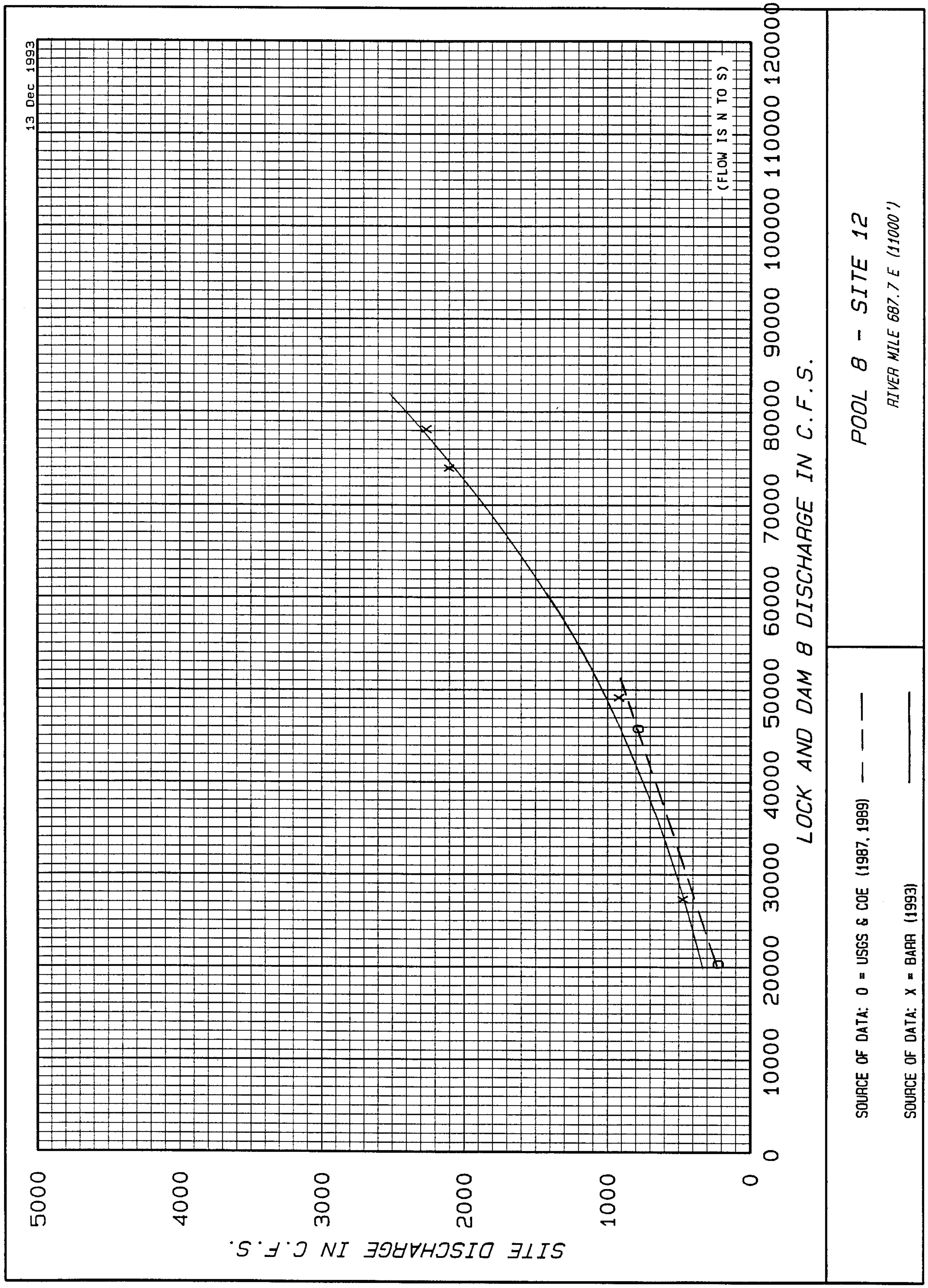

13 Dec 1993
(FLOW IS N TO S)
SITE DISCHARGE IN C.F.S.
0
1000
2000
3000
4000
5000
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
POOL 8 - SITE 12
RIVER MILE 687.7 E (11000')
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: X = BARR (1993)

Figure 15

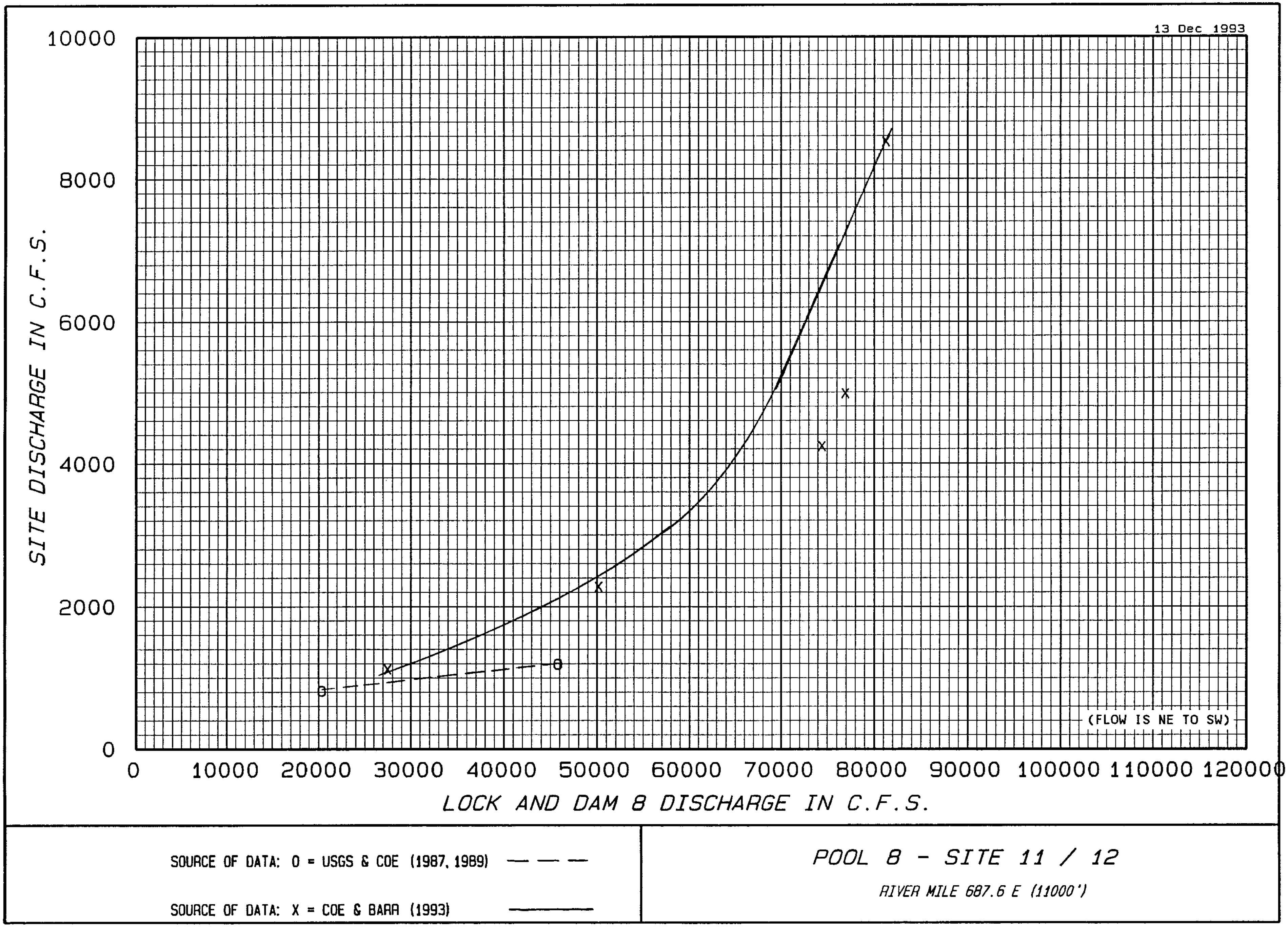

13 Dec 1993
10000
8000
6000
4000
2000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NE TO SW)
SOURCE OF DATA: O = USGS & COE (1987, 1989)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 11 / 12
RIVER MILE 687.6 E (11000')

Figure 16

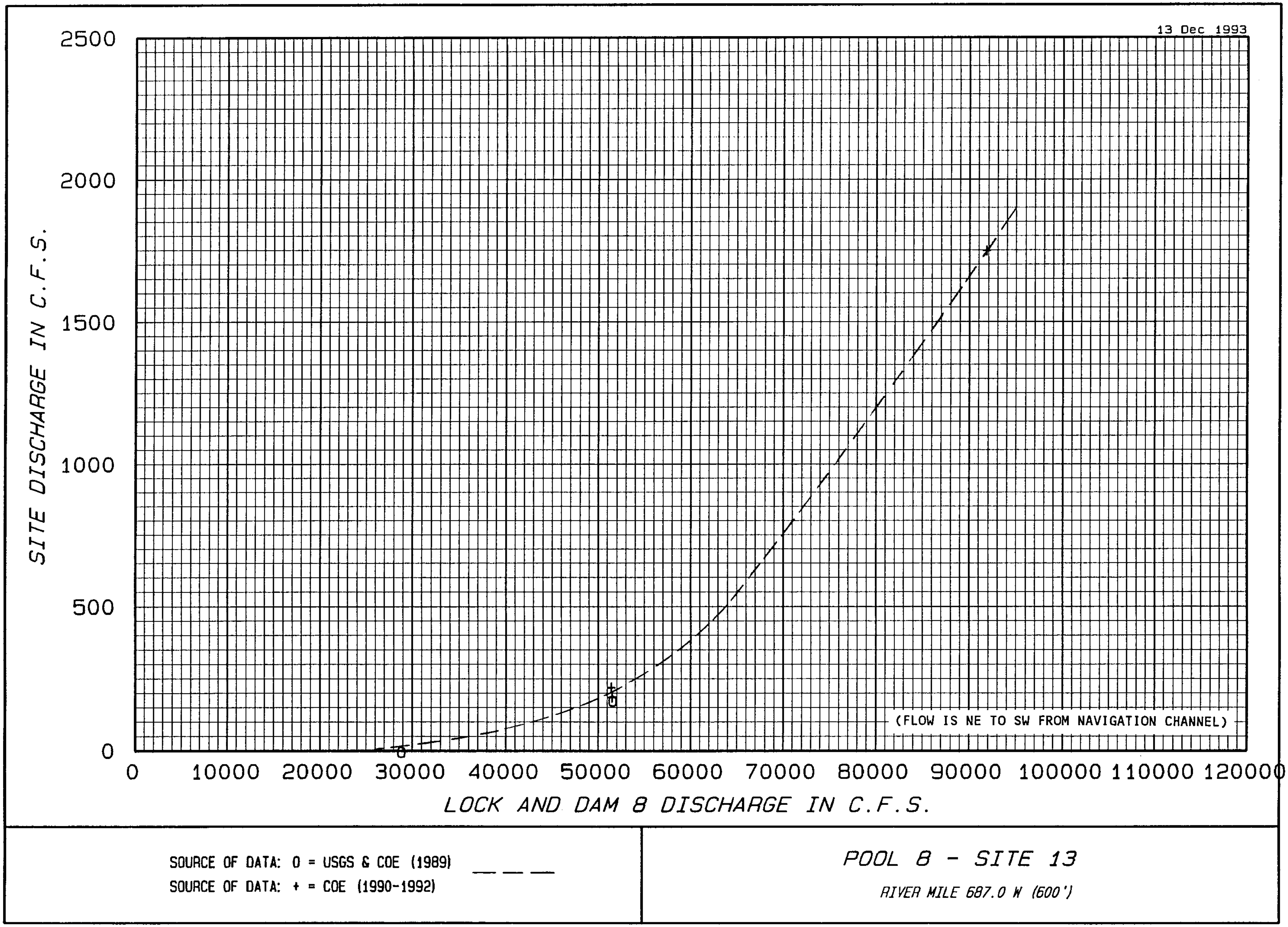

13 Dec 1993
SITE DISCHARGE IN C.F.S.
2500
2000
1500
1000
500
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
SOURCE OF DATA: 0 = USGS & COE (1989)
SOURCE OF DATA: + = COE (1990-1992)
POOL 8 - SITE 13
RIVER MILE 687.0 W (600')

Figure 17

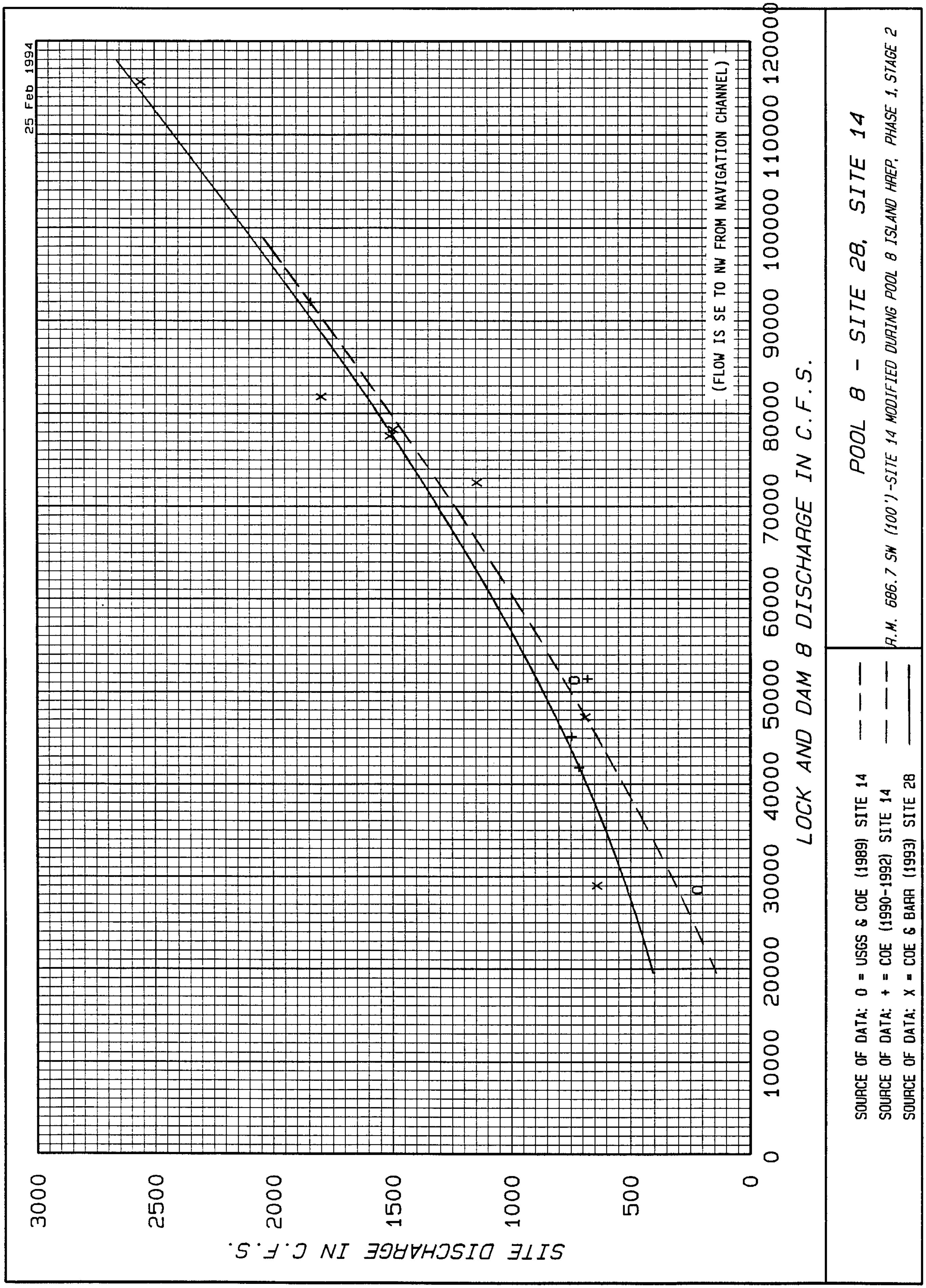
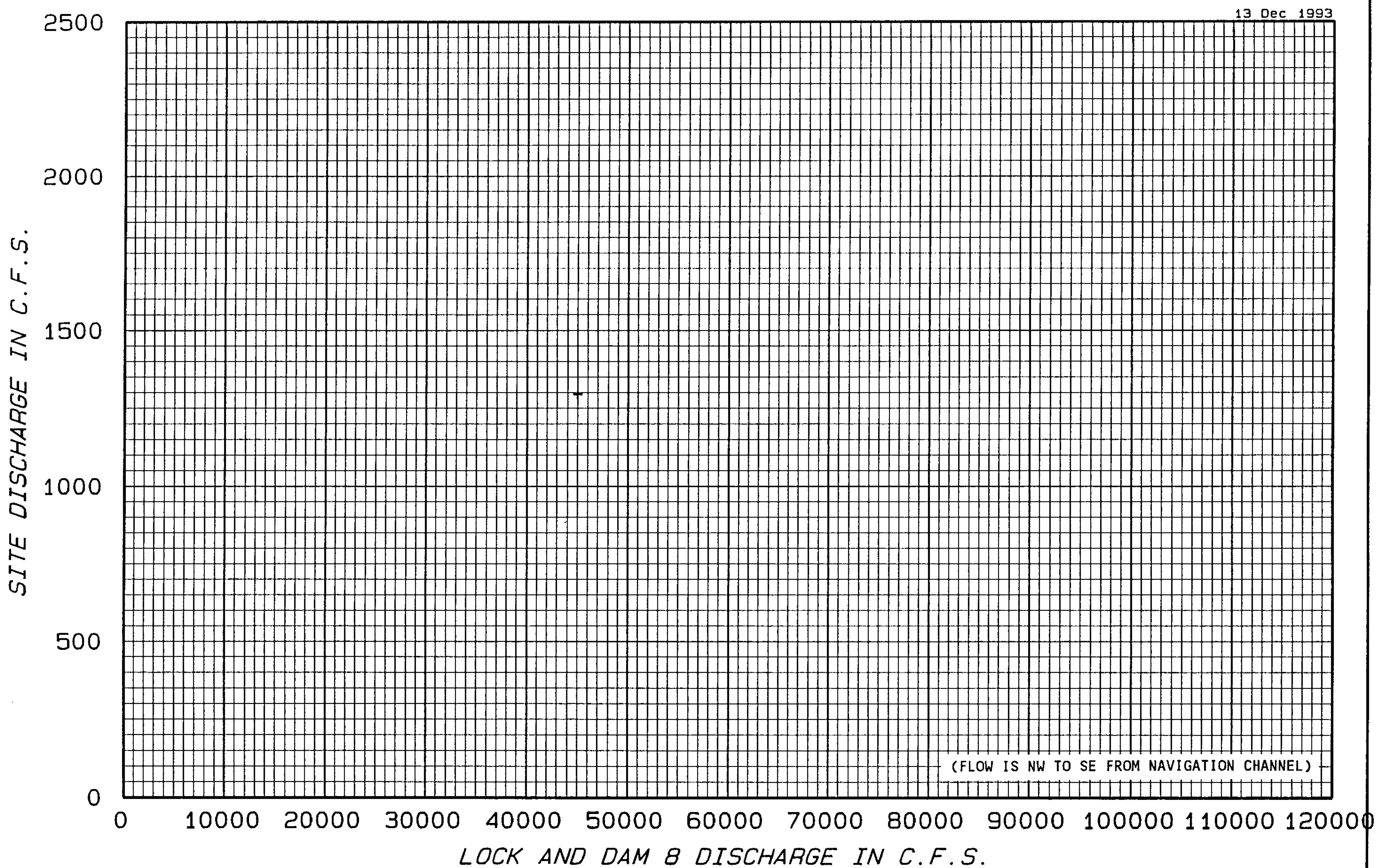

25 Feb 1994
(FLOW IS SE TO NW FROM NAVIGATION CHANNEL)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
0
500
1000
1500
2000
2500
3000
SITE DISCHARGE IN C.F.S.
POOL 8 - SITE 28, SITE 14
R.M. 686.7 SW (100')-SITE 14 MODIFIED DURING POOL 8 ISLAND HREP, PHASE 1, STAGE 2
SOURCE OF DATA: O = USGS & COE (1989) SITE 14
SOURCE OF DATA: + = COE (1990-1992) SITE 14
SOURCE OF DATA: X = COE & BARR (1993) SITE 28

Figure 18



SOURCE OF DATA: + = COE (1990)

POOL 8 - SITE 15

RIVER MILE 686.5 S (800')

Figure 19

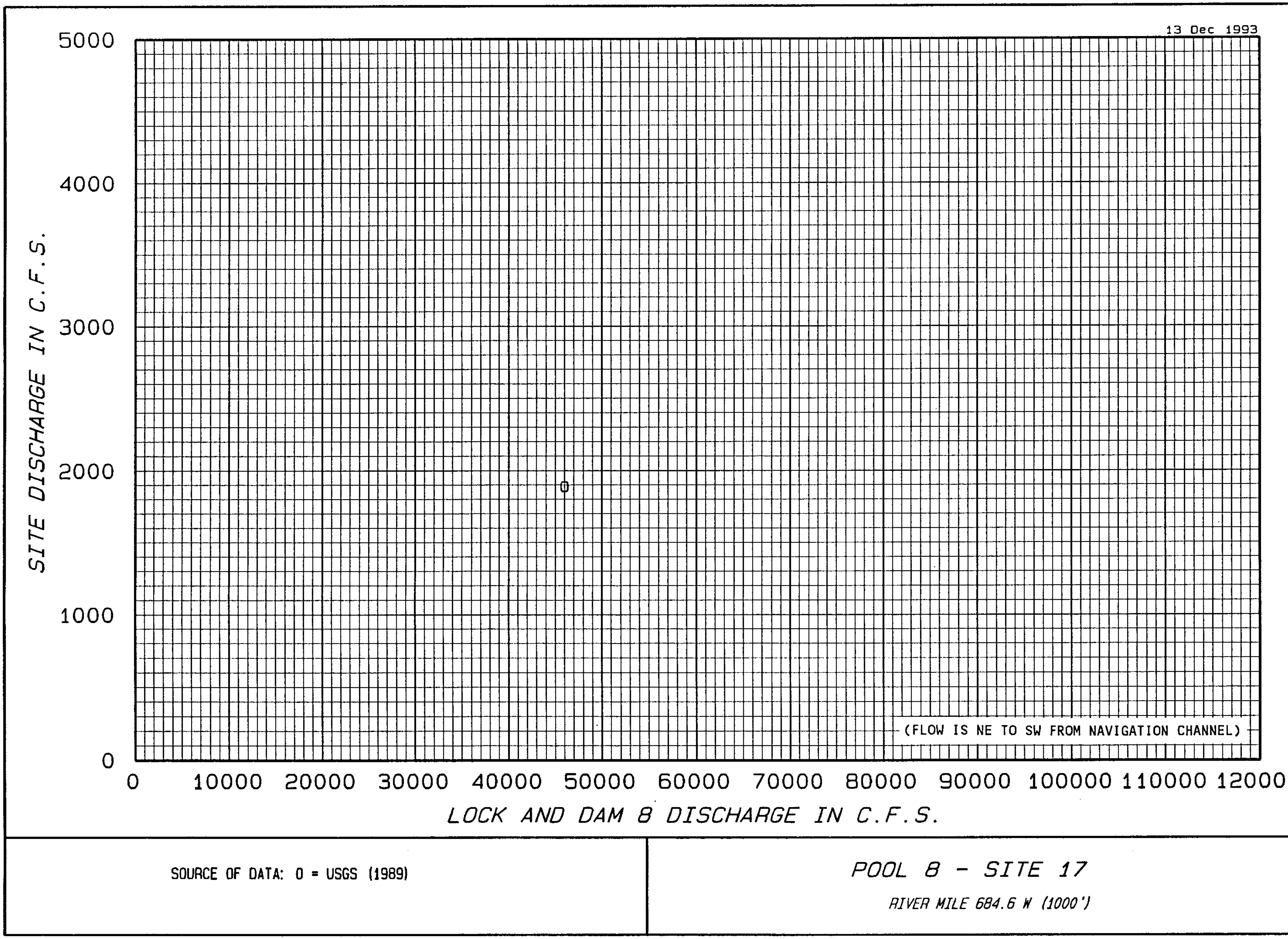
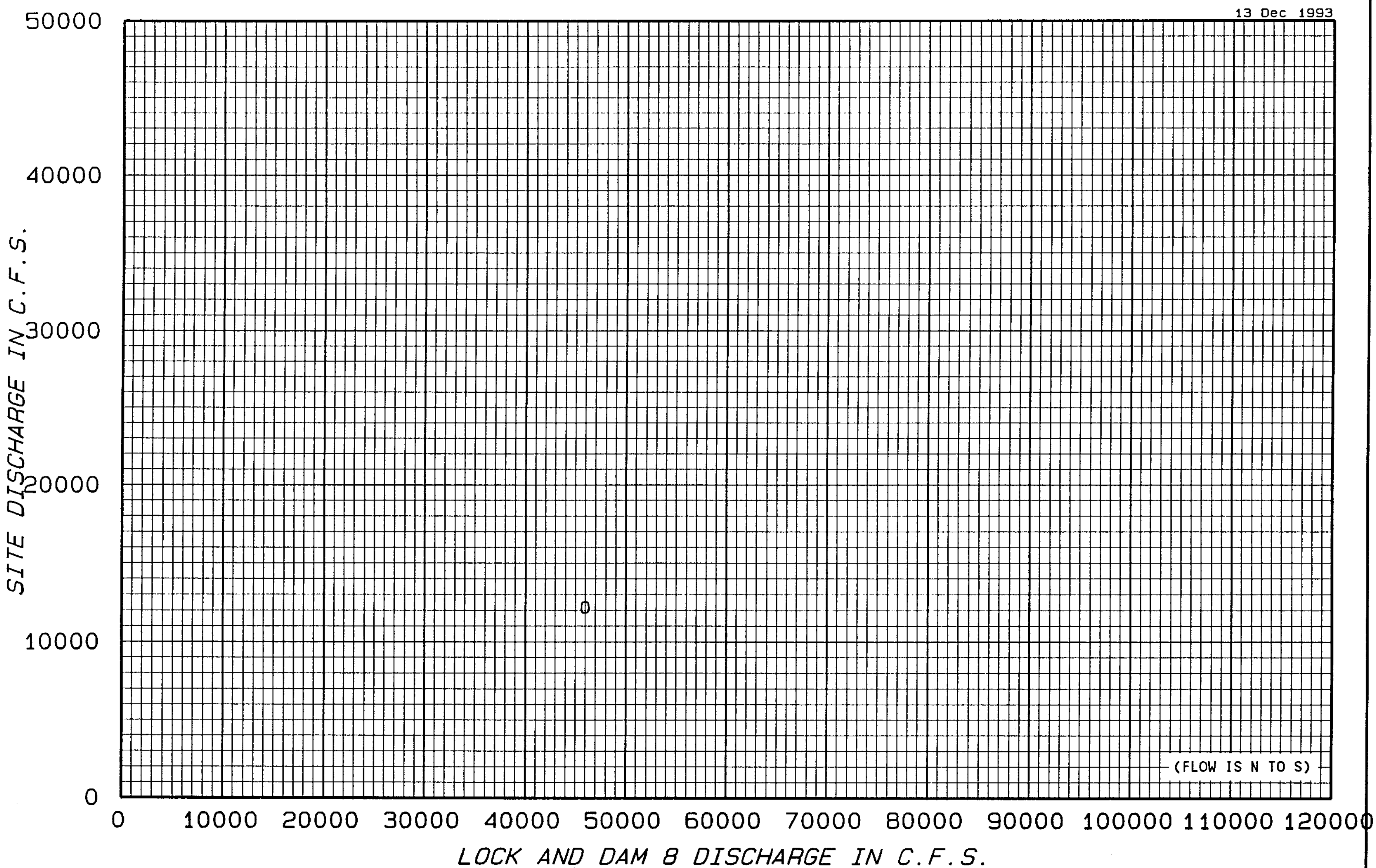

13 Dec 1993
5000
4000
3000
2000
1000
0
SITE DISCHARGE IN C.F.S.
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
SOURCE OF DATA: 0 = USGS (1989)
POOL 8 - SITE 17
RIVER MILE 684.6 W (1000')

Figure 20

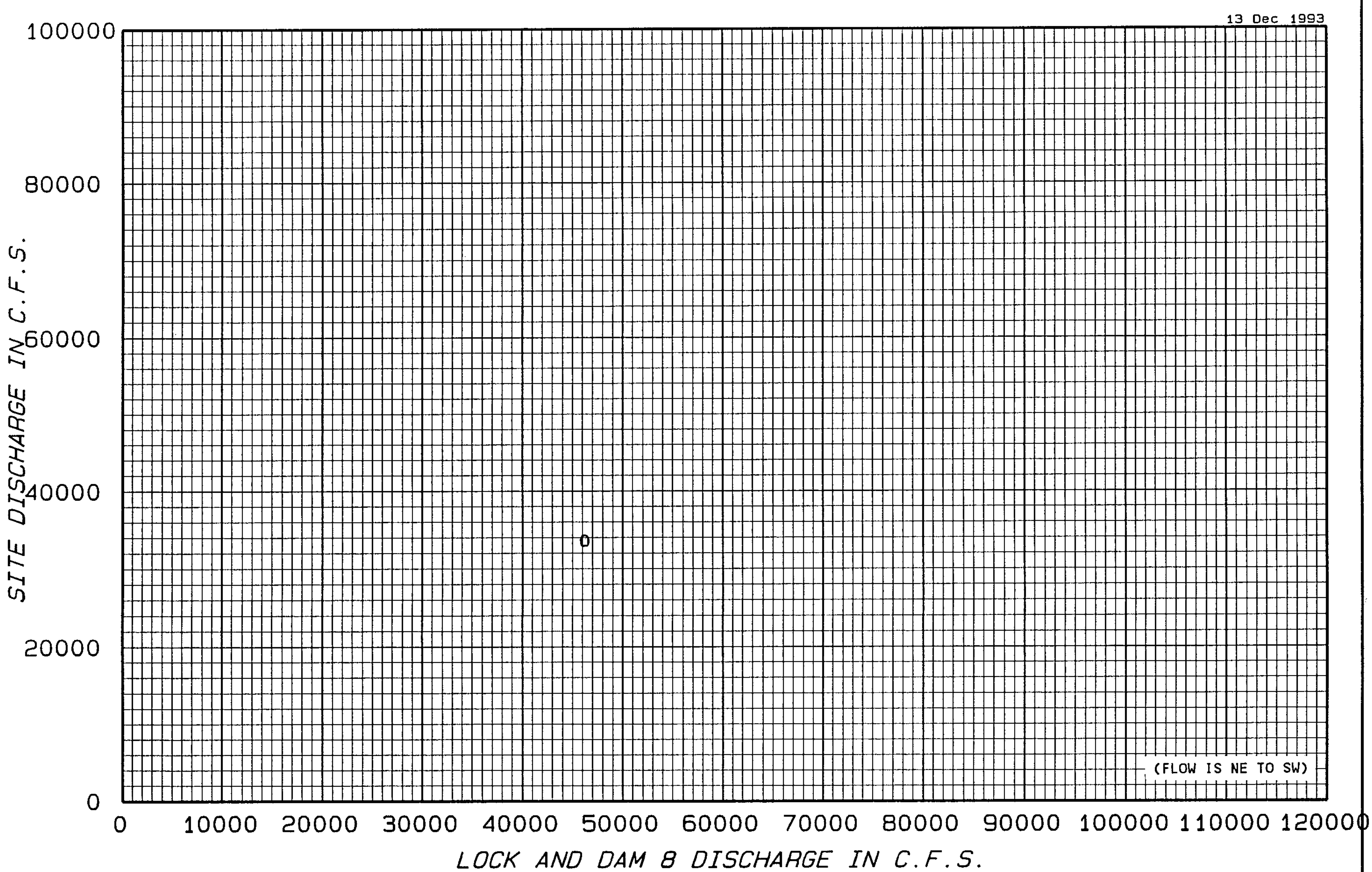


SOURCE OF DATA: 0 = USGS (1989)

POOL 8 - SITE 18

RIVER MILE 683.3 MAIN CHANNEL

Figure 21



SOURCE OF DATA: 0 = USGS (1989)

POOL 8 - SITE 19

RIVER MILE 691.6 MAIN CHANNEL

Figure 22

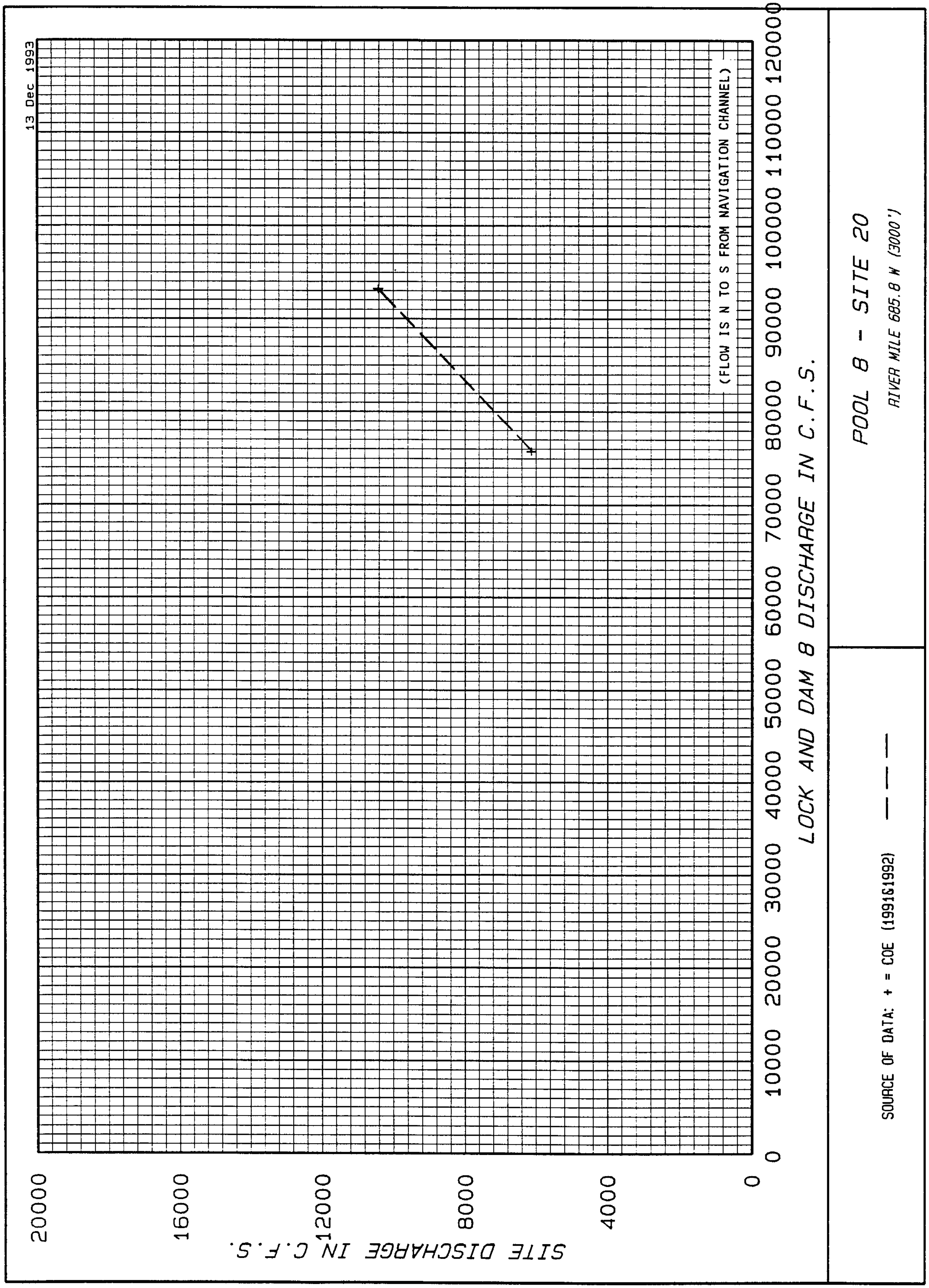

13 Dec 1993
(FLOW IS N TO S FROM NAVIGATION CHANNEL)
LOCK AND DAM 8 DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
SITE DISCHARGE IN C.F.S.
0
4000
8000
12000
16000
20000
POOL 8 - SITE 20
RIVER MILE 685.8 W (3000')
SOURCE OF DATA: + = COE (1991&1992)

Figure 23

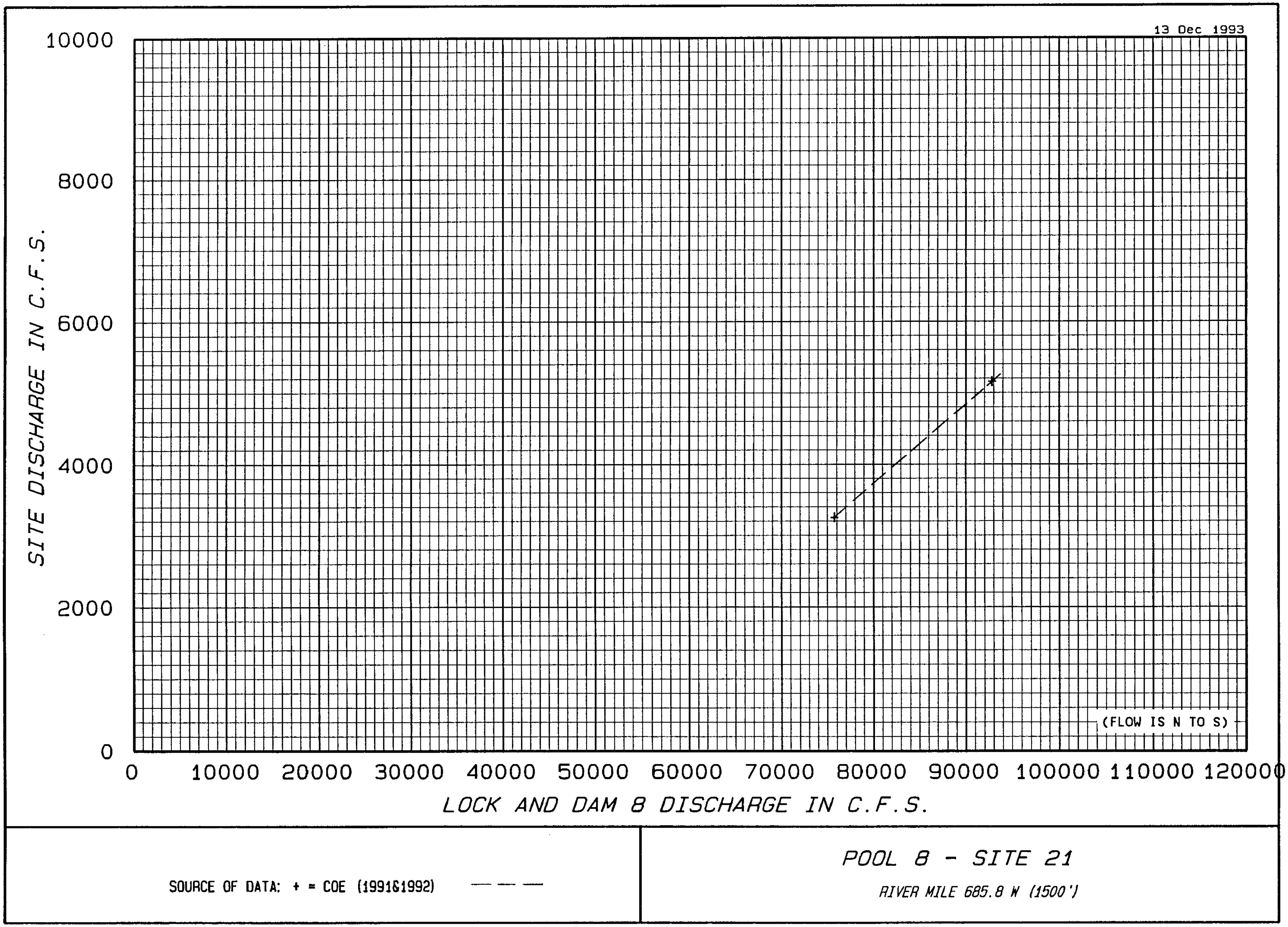

13 Dec 1993
SITE DISCHARGE IN C.F.S.
10000
8000
6000
4000
2000
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS N TO S)
SOURCE OF DATA: + = COE (1991&1992)
POOL 8 - SITE 21
RIVER MILE 685.8 W (1500')

Figure 24

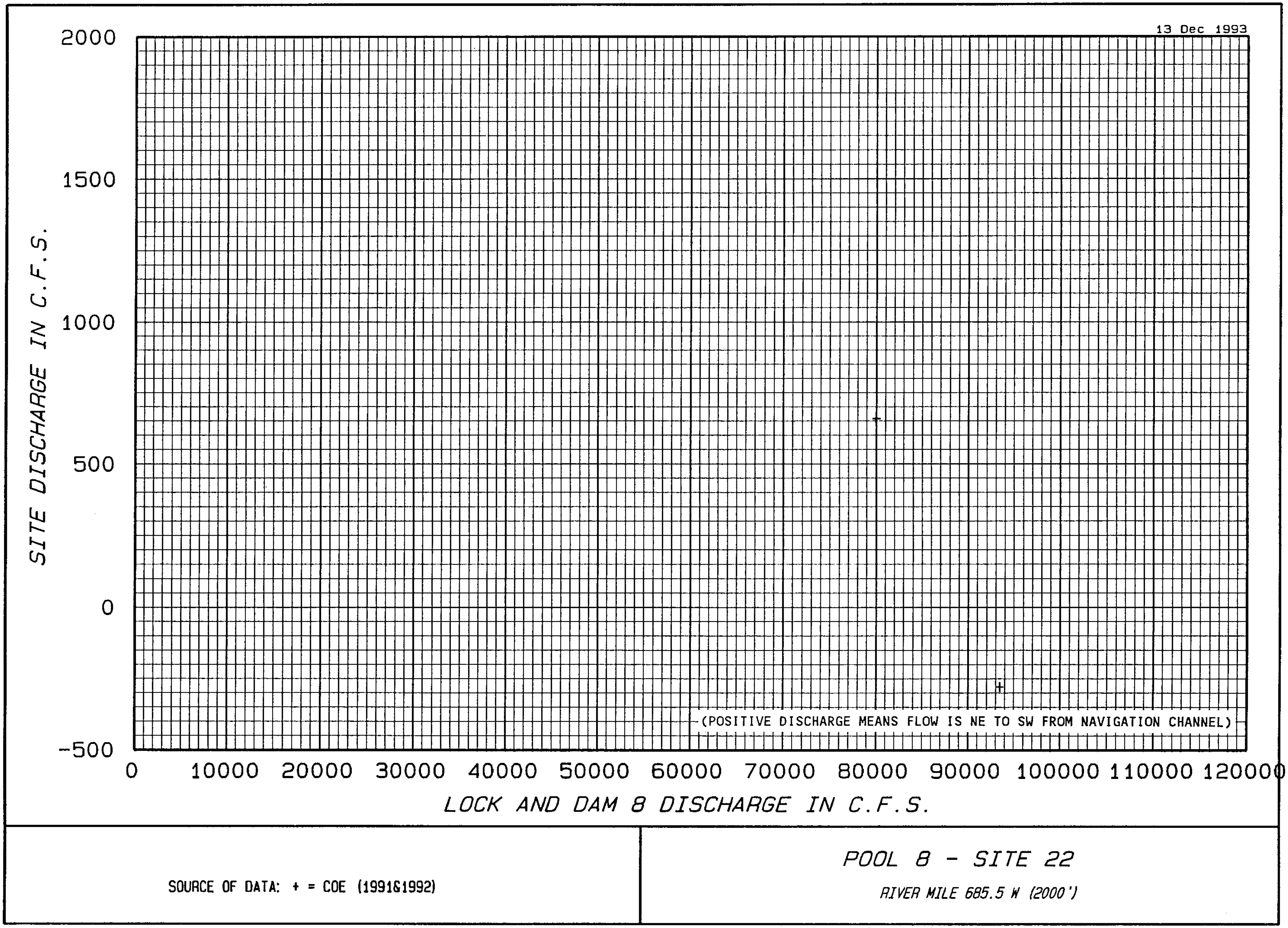

13 Dec 1993
2000
1500
1000
500
0
-500
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(POSITIVE DISCHARGE MEANS FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
SOURCE OF DATA: + = COE (1991&1992)
POOL 8 - SITE 22
RIVER MILE 685.5 W (2000')

Figure 25

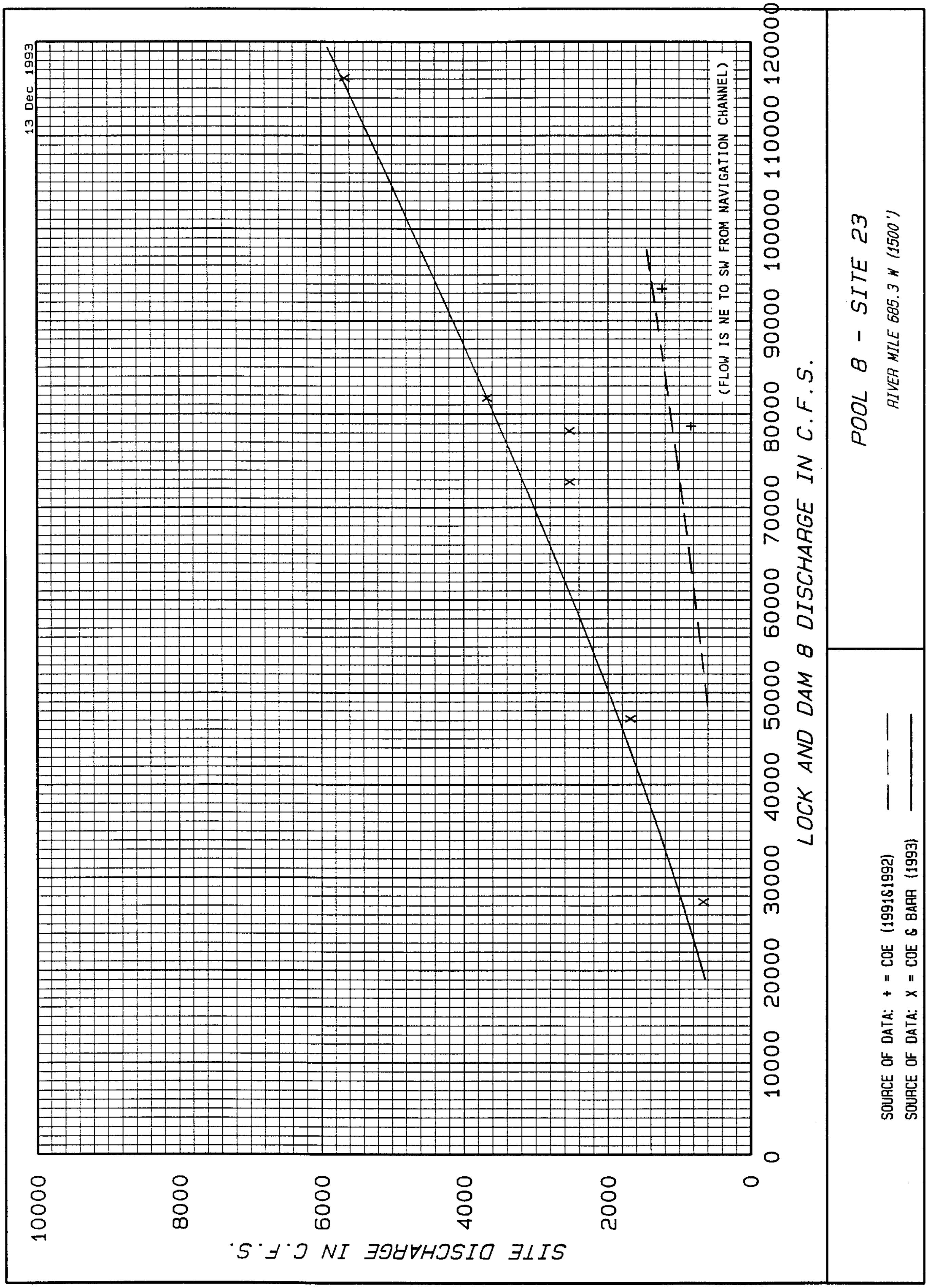
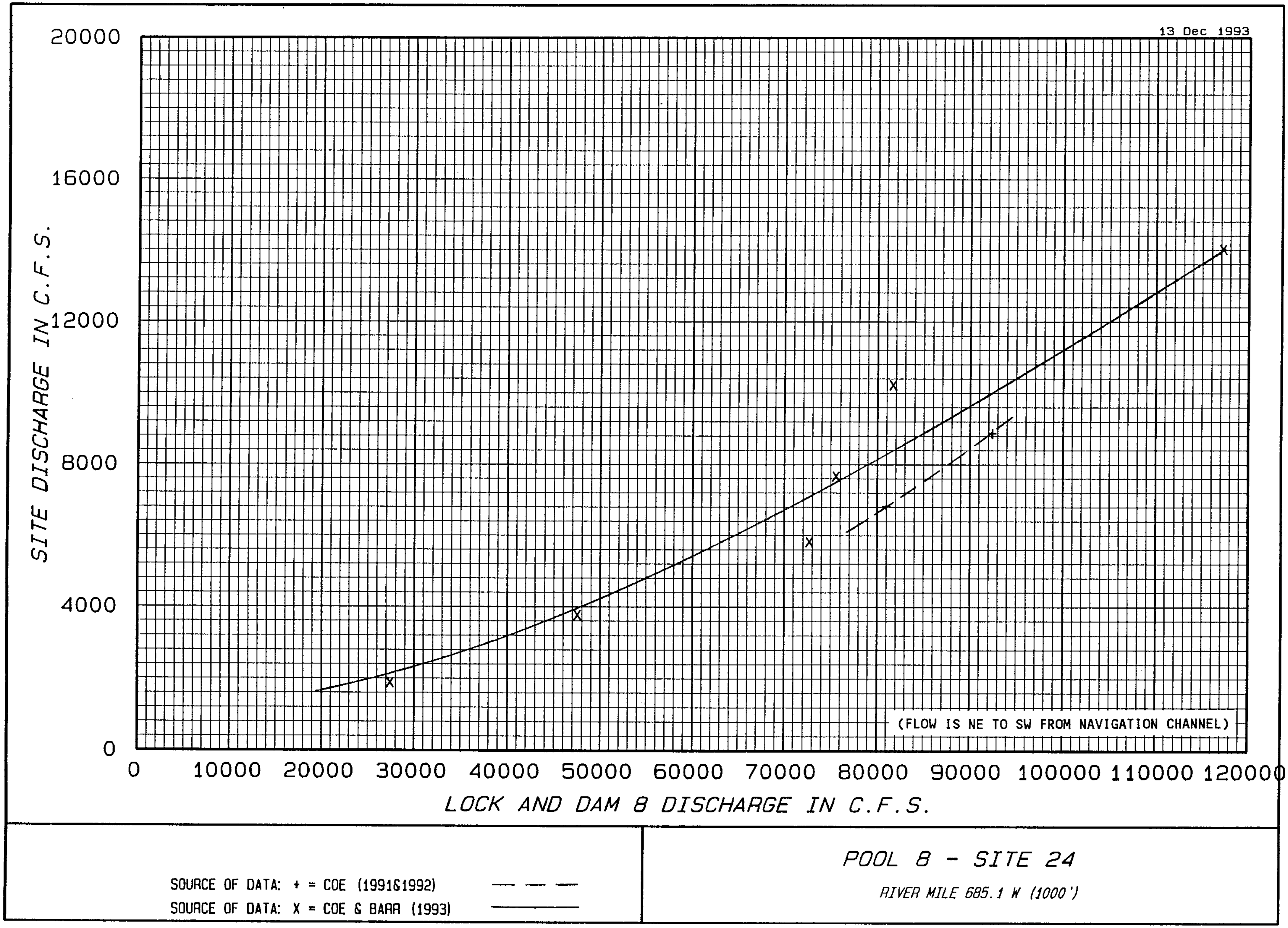

13 Dec 1993
SITE DISCHARGE IN C.F.S.
0
2000
4000
6000
8000
10000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
POOL 8 - SITE 23
RIVER MILE 685.3 W (1500')
SOURCE OF DATA: + = COE (1991&1992)
SOURCE OF DATA: X = COE & BARR (1993)

Figure 26



13 Dec 1993
SITE DISCHARGE IN C.F.S.
20000
16000
12000
8000
4000
0
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
LOCK AND DAM 8 DISCHARGE IN C.F.S.
SOURCE OF DATA: + = COE (1991&1992)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 24
RIVER MILE 685.1 W (1000')

Figure 27

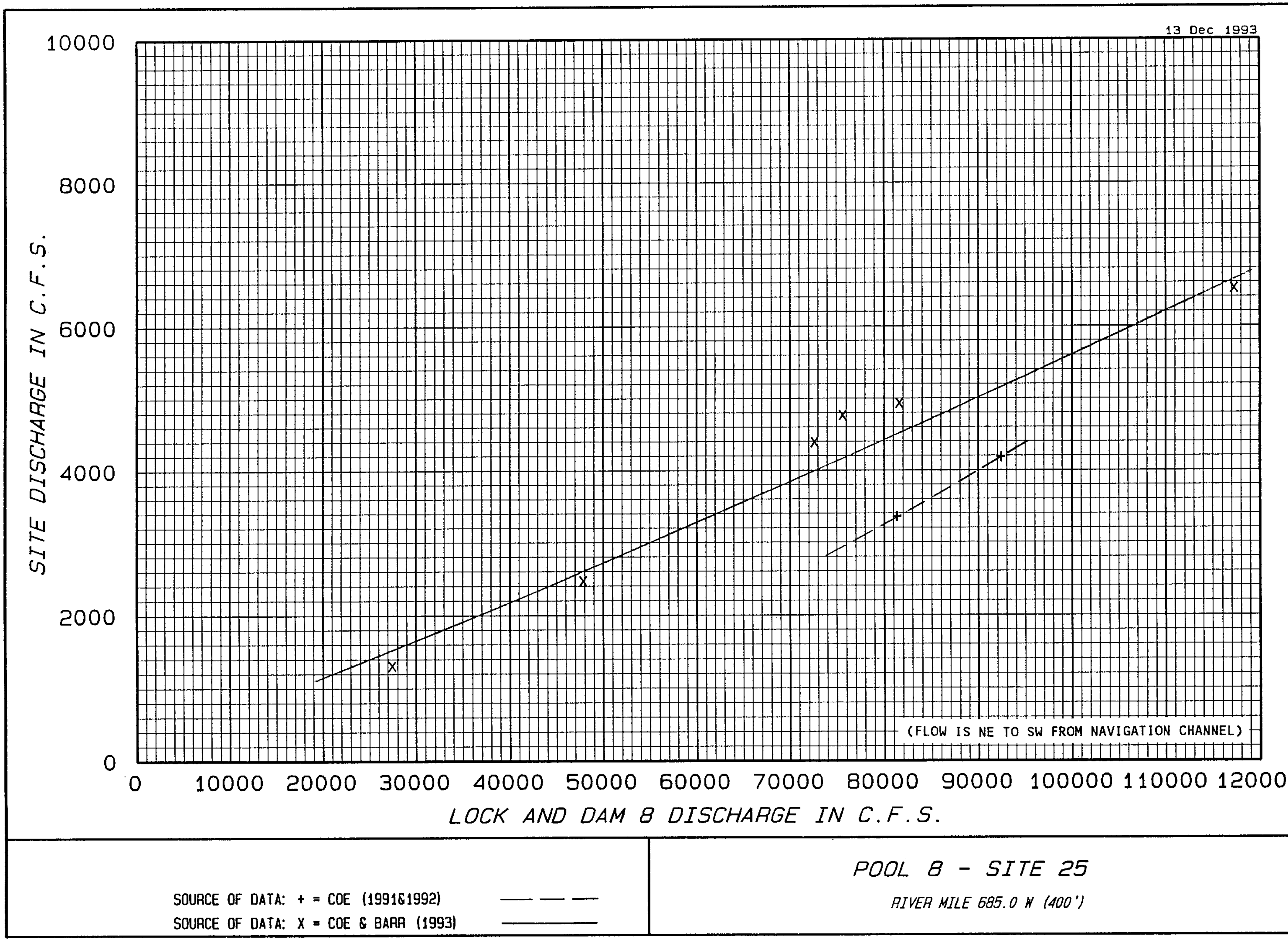
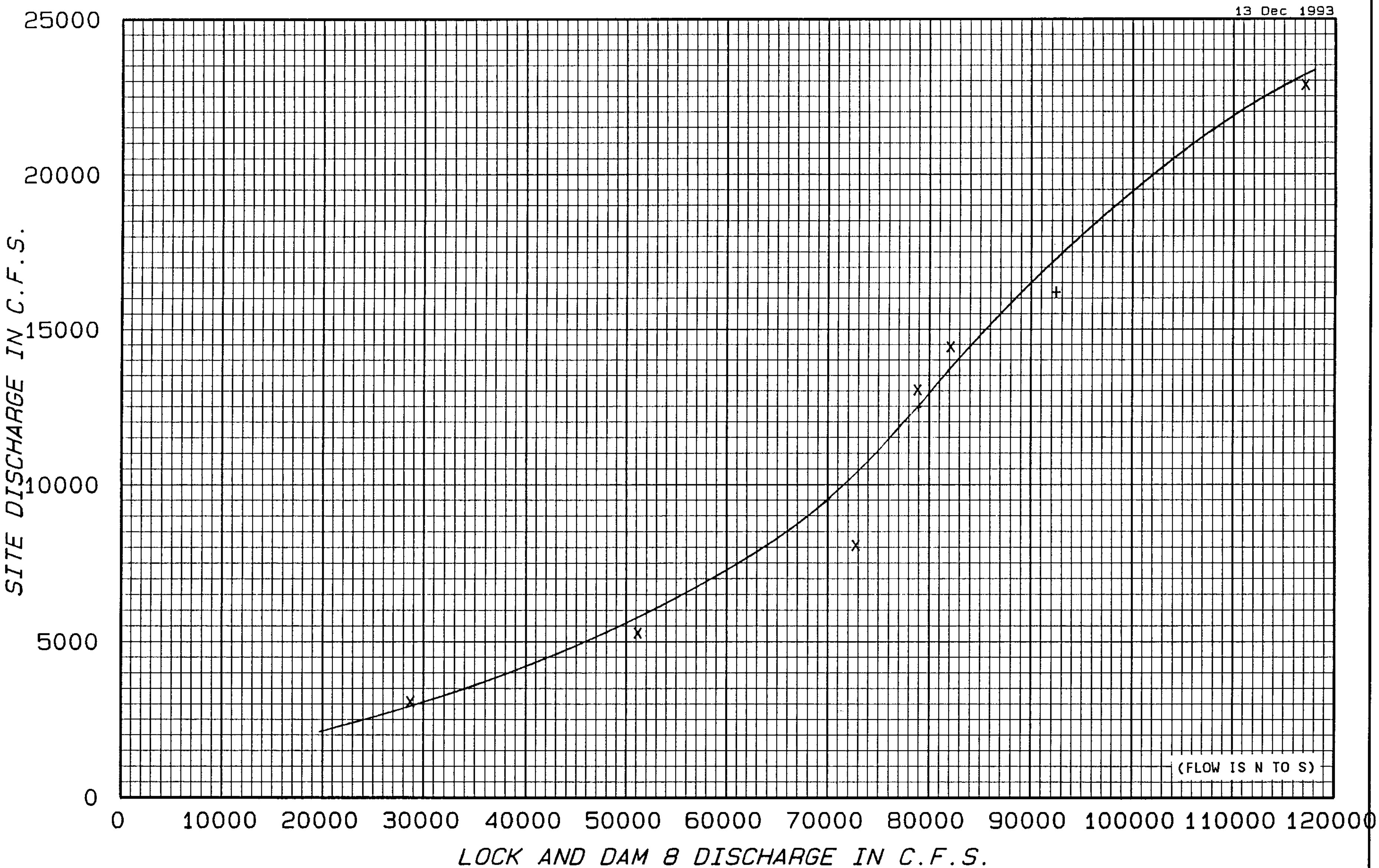

13 Dec 1993
10000
8000
6000
4000
2000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NE TO SW FROM NAVIGATION CHANNEL)
SOURCE OF DATA: + = COE (1991&1992)
SOURCE OF DATA: X = COE & BARR (1993)
POOL 8 - SITE 25
RIVER MILE 685.0 W (400')

Figure 28



POOL 8 - SITE 26

RIVER MILE 685.9 E (3500')

SOURCE OF DATA: + = COE (1992)

SOURCE OF DATA: X = COE & BARR (1993)

Figure 29

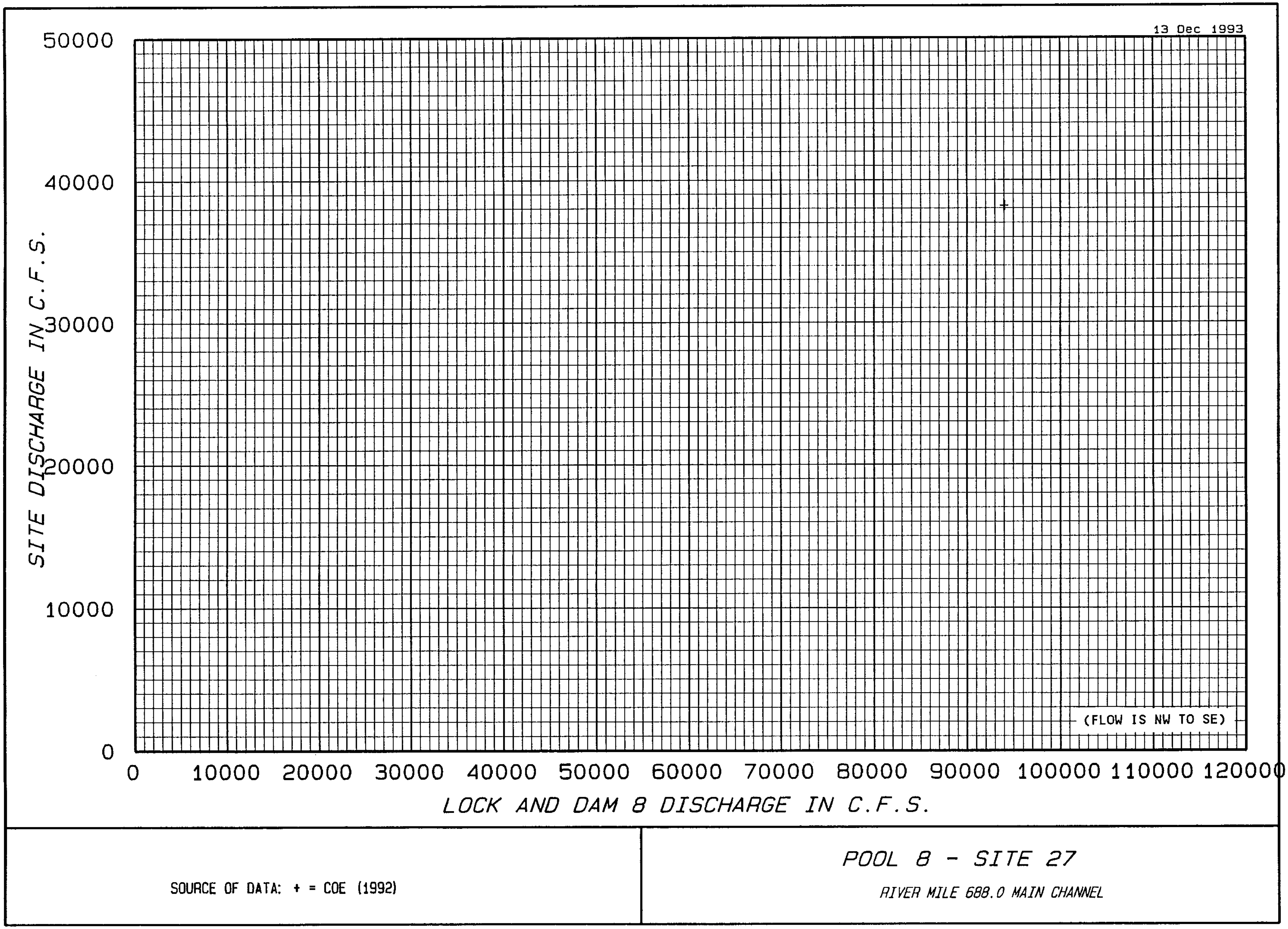

13 Dec 1993
50000
40000
30000
20000
10000
0
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
LOCK AND DAM 8 DISCHARGE IN C.F.S.
(FLOW IS NW TO SE)
SOURCE OF DATA: + = COE (1992)
POOL 8 - SITE 27
RIVER MILE 688.0 MAIN CHANNEL

Figure 30

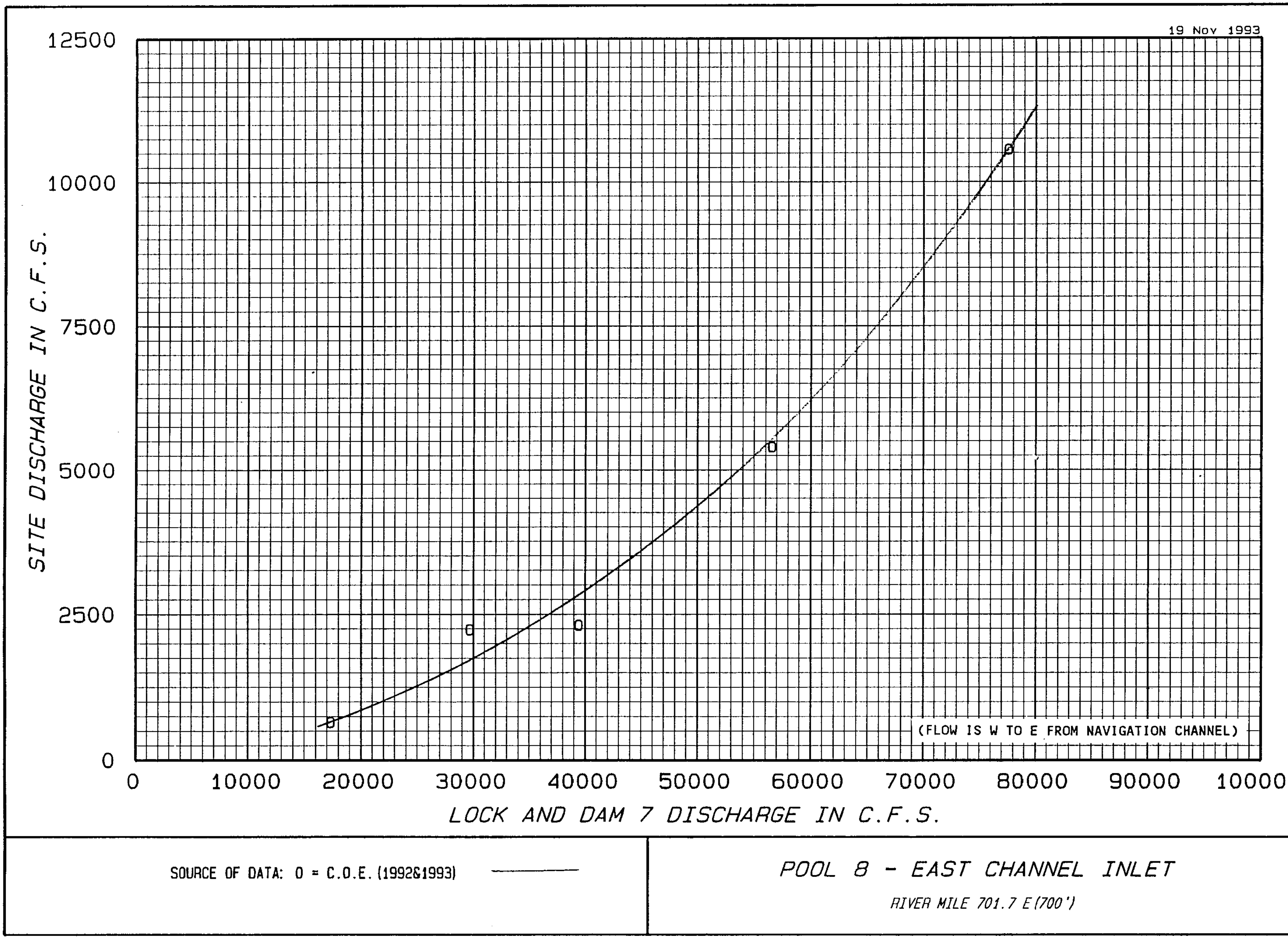
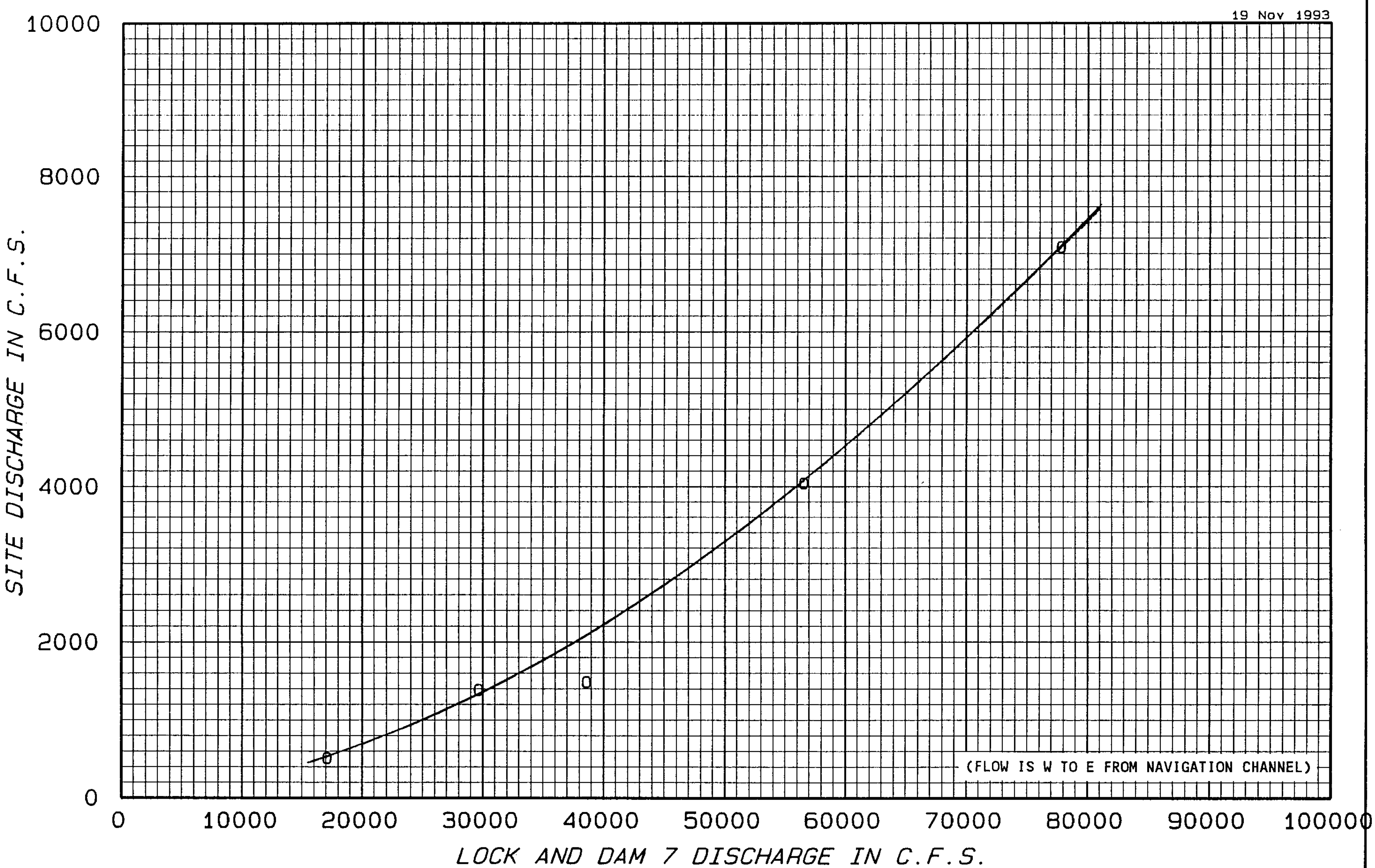

19 Nov 1993
12500
10000
7500
5000
2500
0
SITE DISCHARGE IN C.F.S.
(FLOW IS W TO E FROM NAVIGATION CHANNEL)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 7 DISCHARGE IN C.F.S.
SOURCE OF DATA: O = C.O.E. (1992&1993)
POOL 8 - EAST CHANNEL INLET
RIVER MILE 701.7 E (700')

Figure 31

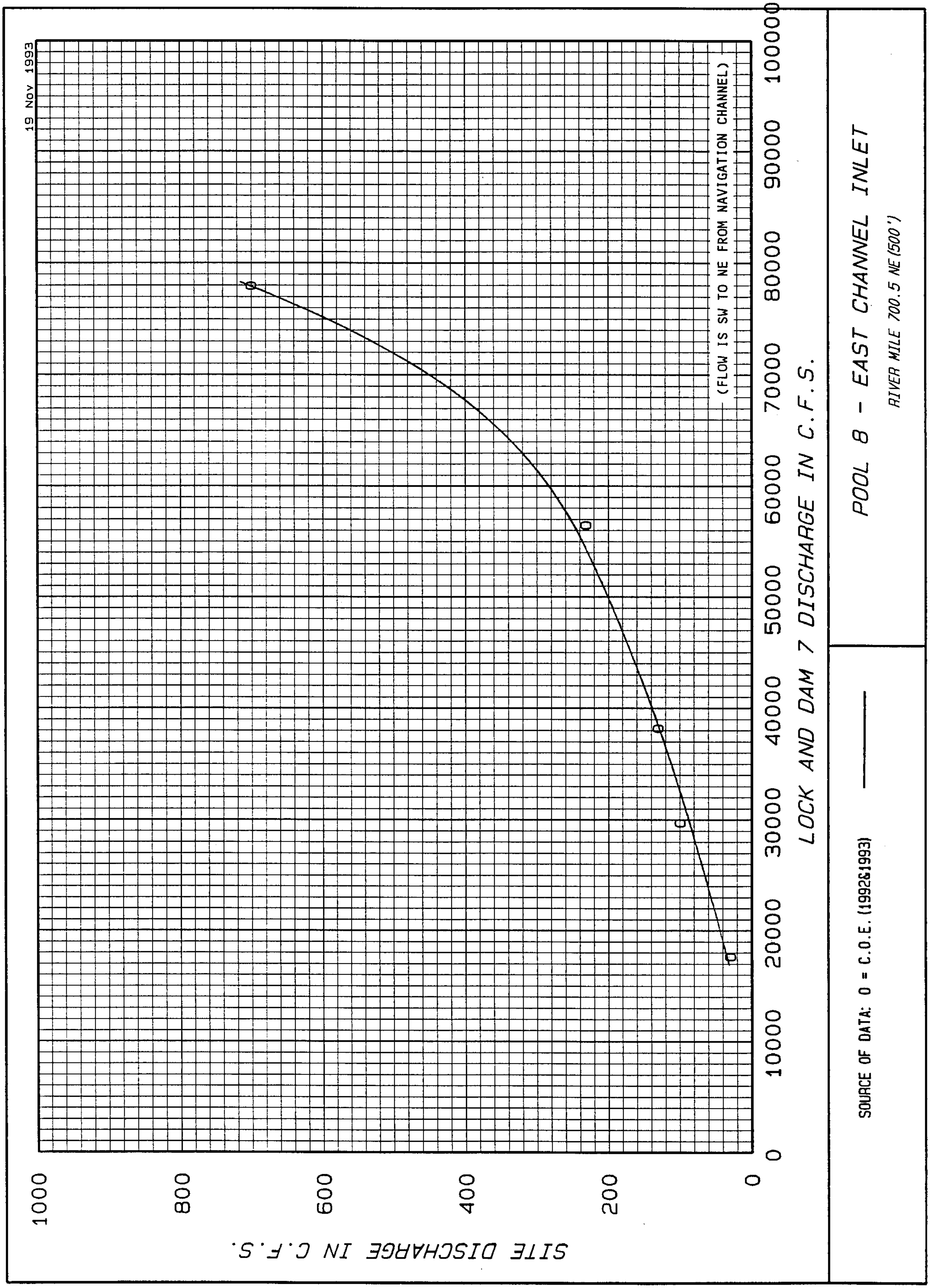


SOURCE OF DATA: O = C.O.E. (1992&1993) ————

POOL 8 - EAST CHANNEL INLET

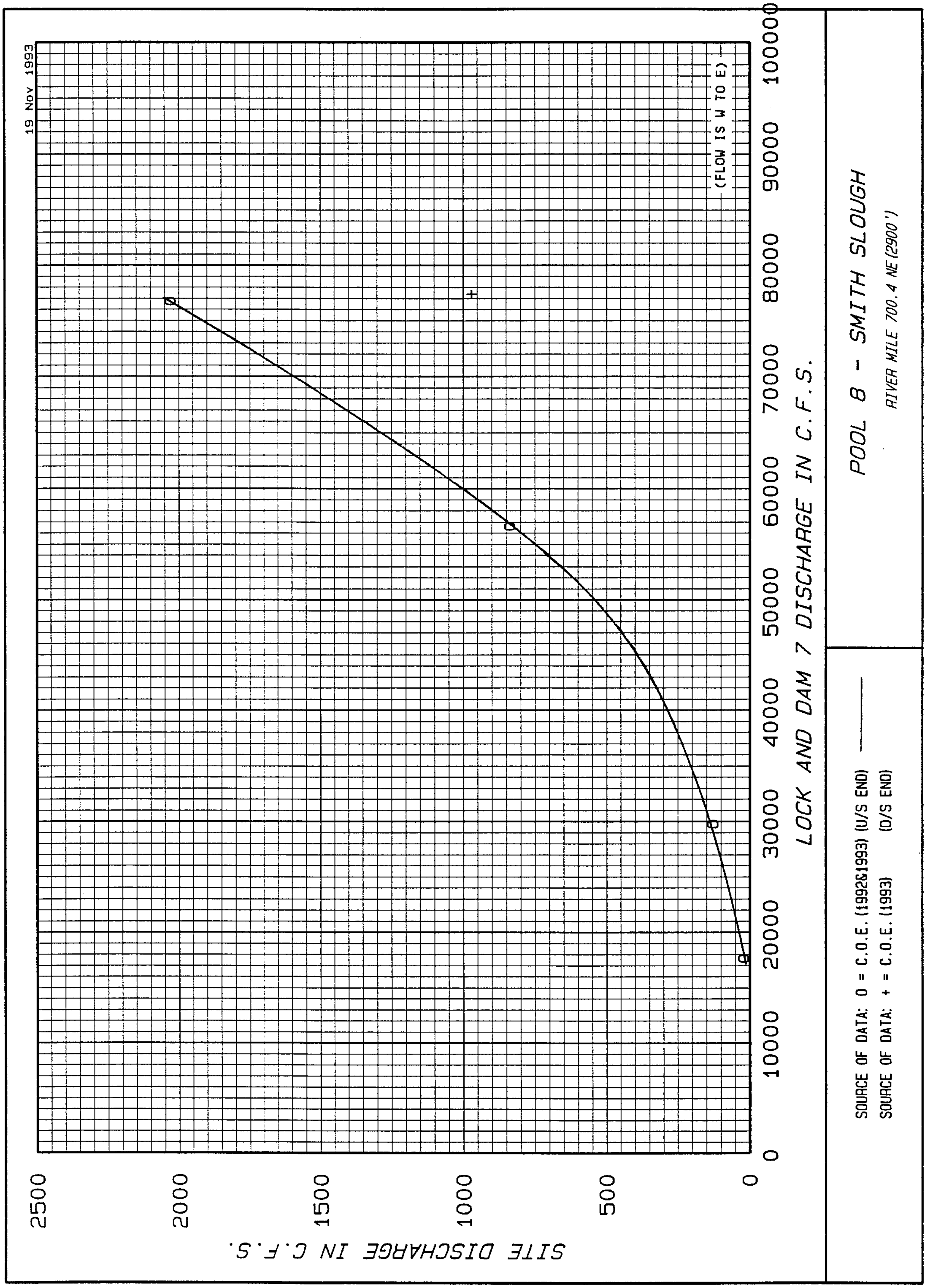
RIVER MILE 701.4 E (900')

Figure 32



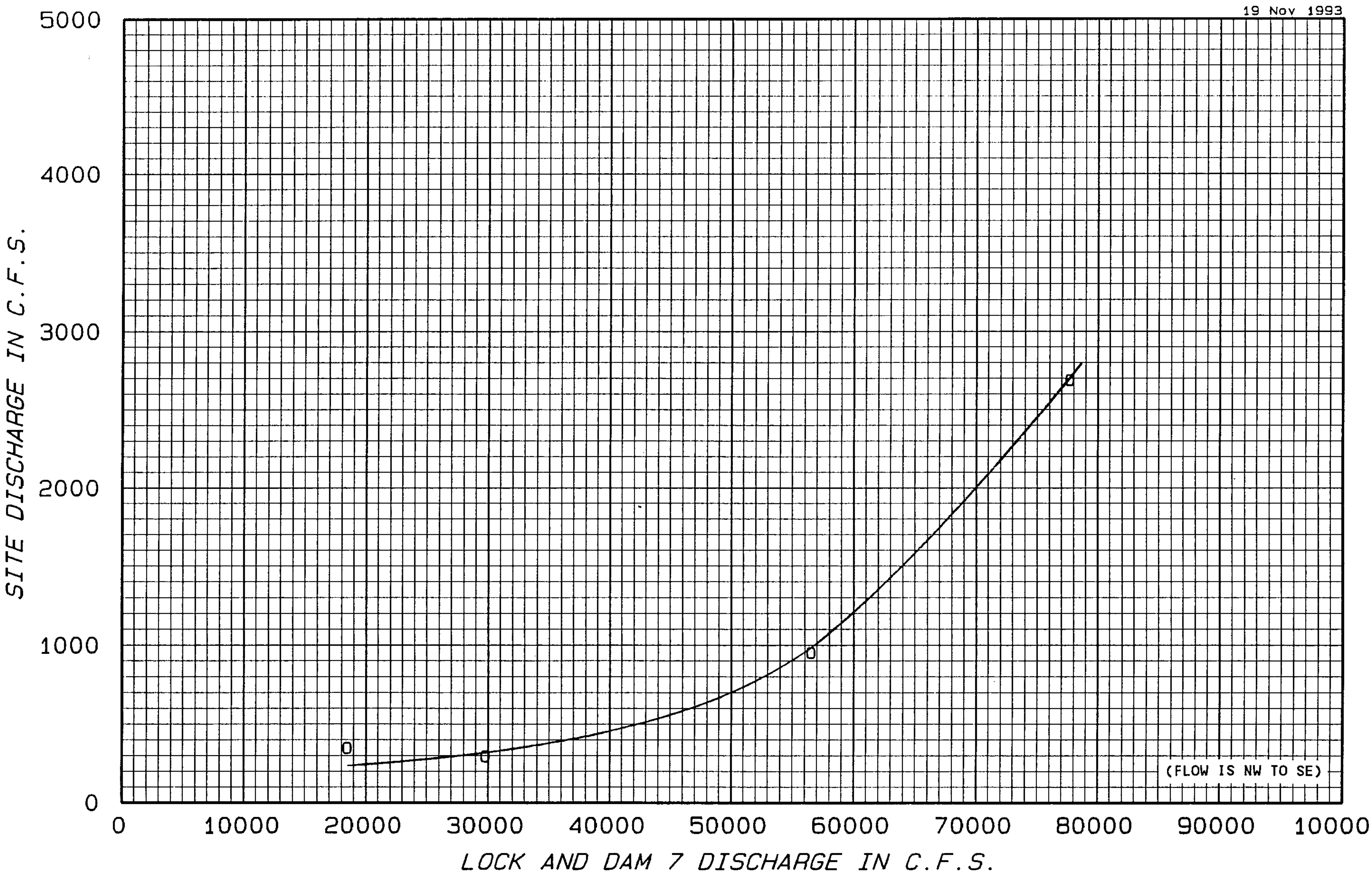
POOL 8 - EAST CHANNEL INLET
RIVER MILE 700.5 NE (500')
SOURCE OF DATA: O = C.O.E. (1992&1993)
19 Nov 1993
(FLOW IS SW TO NE FROM NAVIGATION CHANNEL)
LOCK AND DAM 7 DISCHARGE IN C.F.S.
SITE DISCHARGE IN C.F.S.
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
0
200
400
600
800
1000

Figure 33



19 Nov 1993
(FLOW IS W TO E)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
LOCK AND DAM 7 DISCHARGE IN C.F.S.
0
500
1000
1500
2000
2500
SITE DISCHARGE IN C.F.S.
POOL 8 - SMITH SLOUGH
RIVER MILE 700.4 NE (2900')
SOURCE OF DATA: O = C.O.E. (1992&1993) (U/S END)
SOURCE OF DATA: + = C.O.E. (1993) (D/S END)

Figure 34

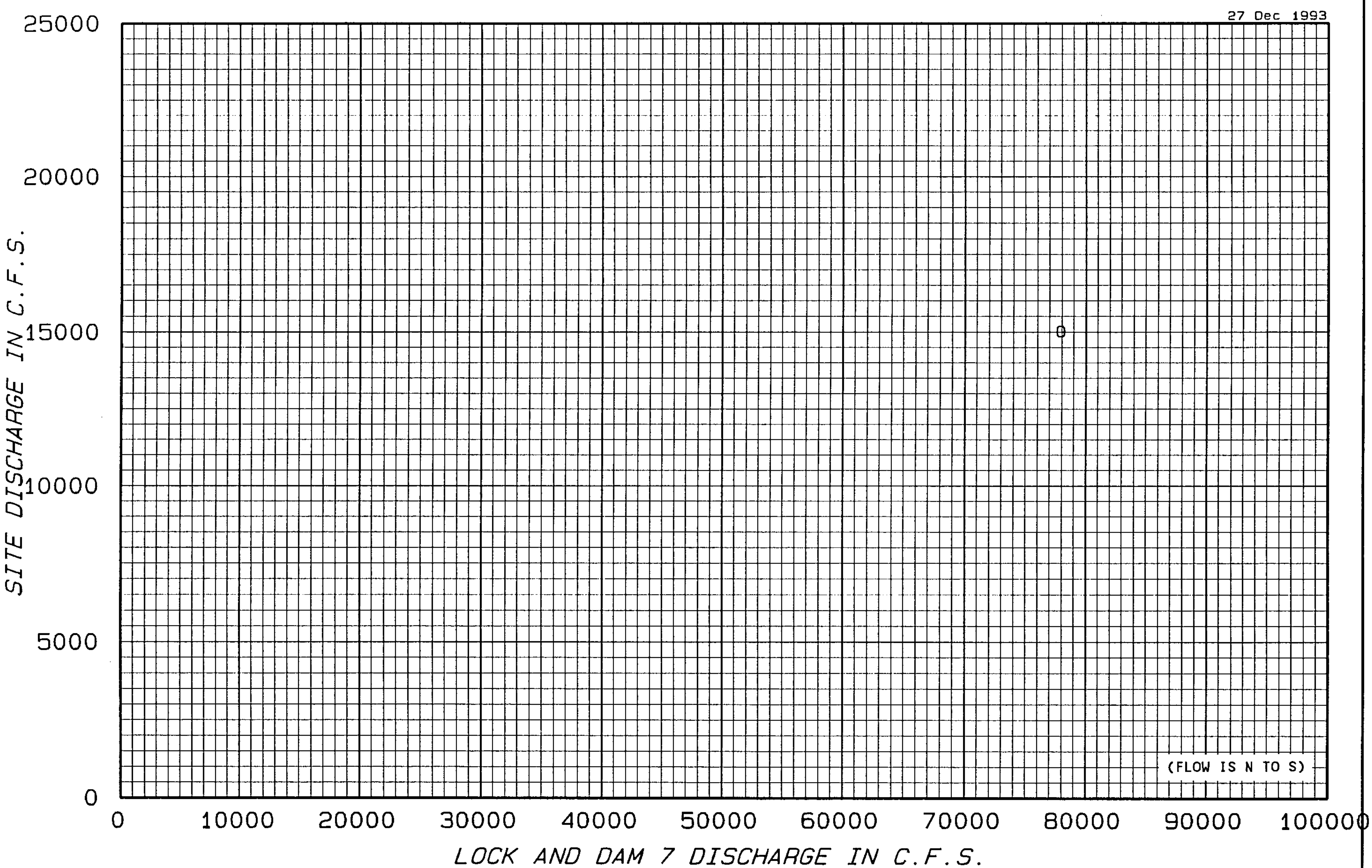


SOURCE OF DATA: 0 = C.O.E. (1992&1993)

POOL 8 - FRENCH SLOUGH

RIVER MILE 700.2 NE (6300')

Figure 35

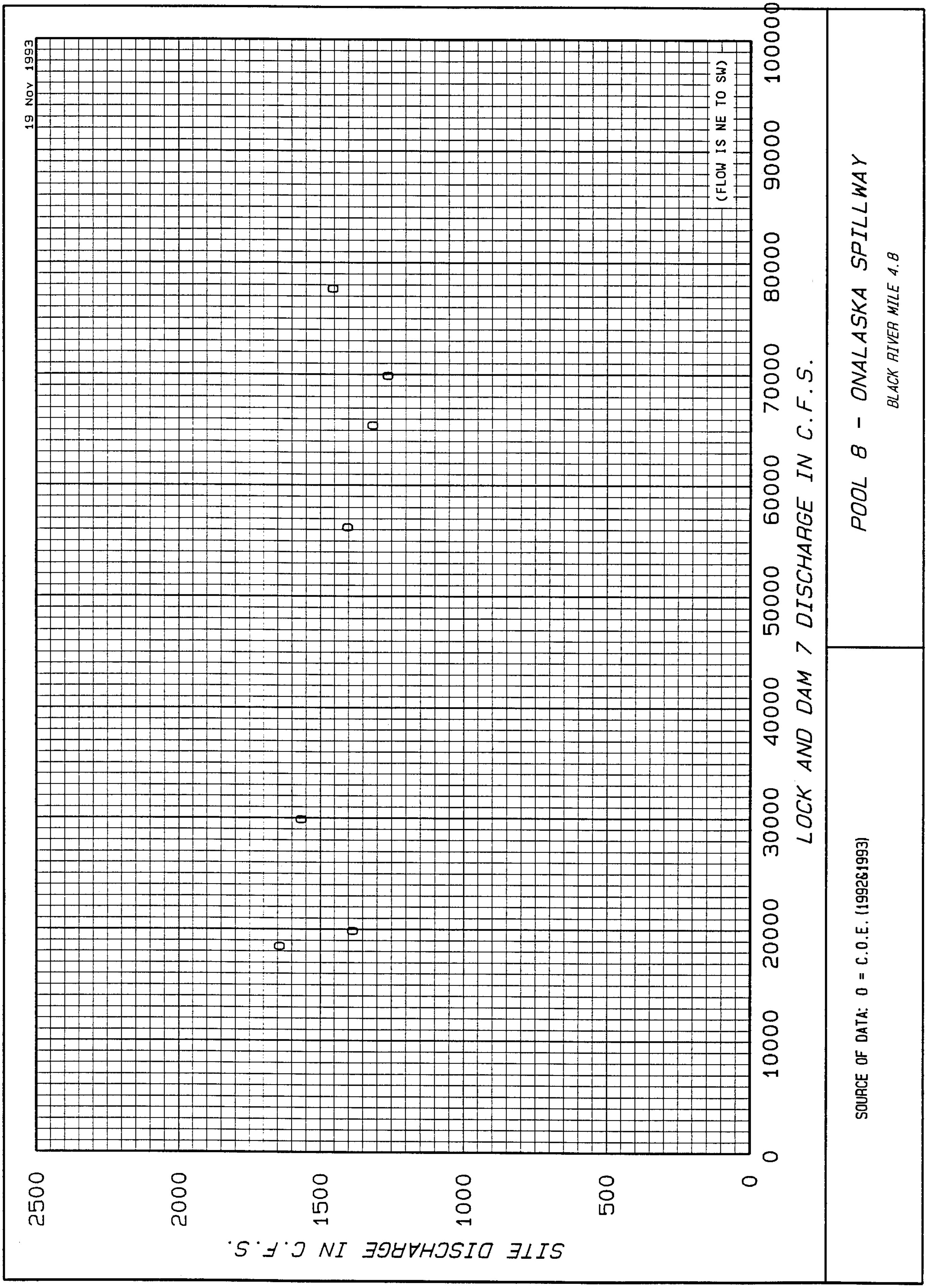


SOURCE OF DATA: O = C.O.E. (1993)

POOL 8 - WEST CHANNEL

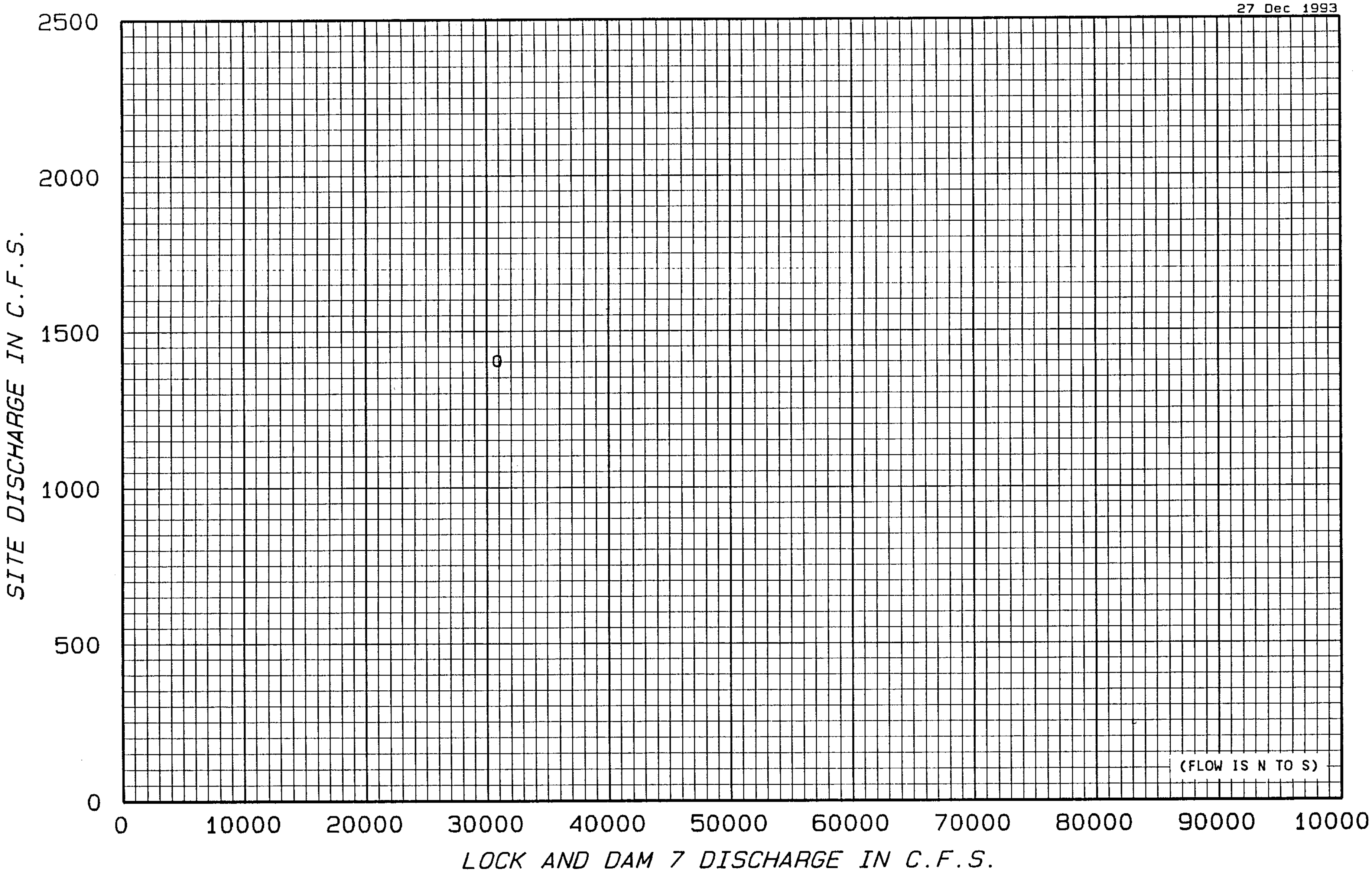
RIVER MILE 699.0 SW (2000')

Figure 36



POOL 8 - ONALASKA SPILLWAY
BLACK RIVER MILE 4.8
LOCK AND DAM 7 DISCHARGE IN C.F.S.
SITE DISCHARGE IN C.F.S.
(FLOW IS NE TO SW)
19 Nov 1993
SOURCE OF DATA: O = C.O.E. (1992&1993)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
0
500
1000
1500
2000
2500

Figure 37

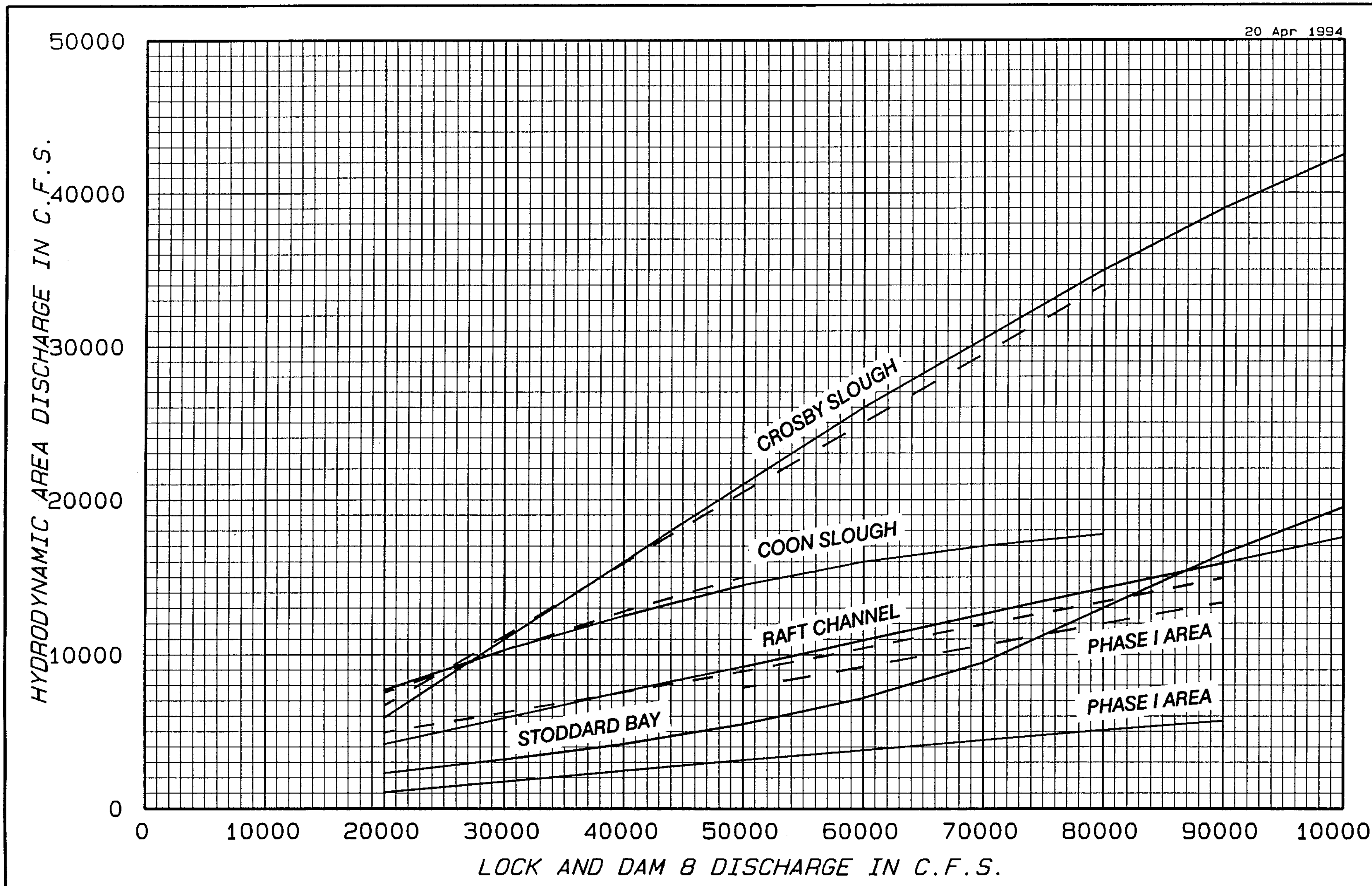


SOURCE OF DATA: O = W.D.N.R. (1987)

POOL 8 - BLACK RIVER

BLACK RIVER MILE 0.7

Figure 38



POOL 8 ISLAND DISCHARGE DISTRIBUTION

Figure 39